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A FORGOTTEN CHAPTER IN THE HISTORY OF THE CIRCULATION OF THE BLOOD *

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THE discovery of the pulmonary circulation is an interesting and debated subject. At least five[1] discoveries are reported and statues have been erected in honor of the authors.

Erasistratus of the Alexandrian School believed that the arteries and the left side of the heart were empty and served to convey the spirit of life to the body. This teaching persisted until Galen disposed of it in the second century A.D., for he showed that by pricking any artery of a living mammal blood gushed forth. He taught that most of the blood from the right side of the heart went through invisible pores in the septum to the left side of the heart. There it mixed with air to create spirit and was distributed to the body. A small portion of this blood in the left side passed back to the lung with each systole to be cleansed of its "soot." He indicated, however, that a small portion of the blood from the right side passed through the vena arteriosa and then by way of the arteria venosa reached the left side. We see, therefore, that Galen had a vague idea of the pulmonary circulation. His errors were a belief in the permeability of the septum and in the systolic reflux.

In 1553 A.D., Michael Servetus[2] described the pulmonary circulation and denied the permeability of the septum but upheld the Galenic theory that the blood in the arteria venosa was mixed with the inspired air and cleansed of its "soot" by expiration.

Fourteen centuries—from Galen to Servetus—pass in silence. During most of this period Arab civilization, besides preserving Greek medicine, made valuable contributions. A manuscript in our possession shows that in the thirteenth century a clear conception of the pulmonary circulation was contributed by Ibn Nafīs,[3] dean of the Mansoury Hospital in Cairo, Egypt.

* A few days ago our attention was called to a valuable article by Dr. Max Meyerhof of Cairo entitled "Ibn An-Nafīs (XIIIth Cent.) and His Theory of the Lesser Circulation," published in the June issue of Isis (No. 65, vol. XXIII. I, pp. 100-120). We had corresponded with Dr. At-Tatawi Bey and in his answer he stated that he had turned over his data to Doctor Meyerhof and had referred our letter to the latter. In his second letter dated March 26, 1935, At-Tatawi Bey stated that he had received an answer from Doctor Meyerhof in which he gives reference to two manuscripts but no mention of any publication or article on the subject.

[1] Michael Servetus, Realdus Colombus, Carlo Ruini, Andreas Cesalpinus, François Rabelais. They all lived in the sixteenth century.

[2] In his Christianismi Restitutio.

[3] Abū-l-Ḥasan Alā-ŭd-Dīn Ali ibn Abi-l-Ḥazm (known as Ibn Nafīs). Brockelmann calls him Abu-el-Harm. The *z* and *r*, in Arabic, look very much alike with the exception that the *z* has a dot over it. Evidently Brockelmann overlooked the dot over his *r*.

Ibn Nafīs studied medicine in Damascus. The famous biographer and bibliographer, Ūsaibi'ā,[4] was his contemporary. They both studied under the same teacher[5] in Damascus and worked together in the Mansoury Hospital of Cairo, and yet the latter made no mention of the former in his biography. Ūsaibi'ā left Cairo and came to Sālkhăd—from the fleshpots of Egypt to the border of the Syrian desert. We wonder if Ibn Nafīs was responsible for that departure and whether the omission was intentional. It is unfortunate that Ūsaibi'ā has failed to give us what would have been valuable first-hand information about one of the brilliant characters of the thirteenth century. However, we are not left totally in the dark for several other biographers[6] have given us a fairly complete record of the life and work of Ibn Nafīs.

Ibn Nafīs is portrayed to us as one of the greatest physicians of his age, equal to Avicenna and even surpassing the latter in treatment. Besides medicine, he excelled in language, philosophy, Moslem canon law and traditions. He was a free thinker and one of the chief exponents of unitarianism. Unlike most of his predecessors he was a keen observer and a careful recorder of facts. His love for truth and his logical mind made him refuse to follow accepted authority blindly. He was a voluminous writer, writing fully and intelligently from memory without reference to any book. He wrote at least

Several letters of the Arabic alphabet have no equivalent in any of the European alphabets. Hence in translating Arabic manuscripts into any European language, certain proper nouns cannot be properly spelled to convey the exact Arabic pronunciation. Several systems have been adopted empirically—mostly by Orientalists—to overcome this difficulty, but none of these have been found satisfactory, as the same word may be pronounced differently by a Britisher, a Frenchman, an American, a German, or an Italian.

We must also bear in mind that the same word may be pronounced differently in the various Arabic speaking countries, and even in different sections of the same country. An American living and studying in Syria may pronounce the same word differently from one living in Egypt, Mesopotamia or Arabia.

In this article we have used the spelling that would convey to an English speaking reader the most nearly correct pronunciation.

[4] Mūwaffăq-ŭd-Dīn Aḥmad Ibn-il-Qasīm Ibn Abi Ūsaibi'a, the author of Ūyūn-ŭl-Anbā fi Tabăqāt-il-Atibbā, which contains, beside a brief history of Greek medicine, a complete biography of over 400 Arab physicians.

[5] Mūhăth'thăb-ŭd-Dīn Ad-Dakhwār.

[6] As-Safadi (695–764 A.H.), the first volume of whose book is already printed in Germany, and Moḥammad ŭl-Baqir in his Rowdāt ŭl-Jānnāt, have both given us excellent records of Ibn Nafīs. Five other biographers: Ibn-us-Sabki, Tabaqāt-us-Sabki; Tash Kubri Zadā, Mūtah-ŭs-Sa'adāh; Siyouti, Hosn-ul-Mohathara; Al-Hanbali, Sha'tharat-ŭth-Thāhab; Hajji Khalifā, Kashf-ŭz-Zūnūn, have also given us portraits of him.

[7] The following is a list of his known medical books:

(1) Ash-Shāmil, an encyclopedia of medicine which would have exceeded 300 volumes if it had been completed. He wrote only 80 volumes, most of which have been lost, only a few fragments being found in the Bodleian Library (Nos. 536–539).

(2) Al-Mūhath'thab f-il-Kuḥl, a treatise on eye diseases.

(3) Al-Mūkhtār min-al-Agthi'ya, a book on diet.

(4) Sharh Fūsūl Abicrāt, a commentary on the Aphorisms of Hippocrates.

(5) Sharḥ Taqdimat-ŭl-Ma'rifā, a commentary on the Prognostica of Hippocrates.

(6) Sharḥ Masā'il Ḥunein Ibn Ishāq, a commentary on the Questionary of Hunein Ibn Ishāq.

ten books[7] on various medical subjects and a book entitled the "Perfect Man."[8] This latter expounds the author's unitarian belief and teachings, such as that for which Servetus suffered martyrdom. There is a striking parallelism in the fact that both described the pulmonary circulation in the course of a theologic discussion and made the same mistakes in practically the same phraseology.

In the manuscript in our possession[9]—Commentary on the Anatomy of the Canon of Avicenna—Ibn Nafīs clearly and repeatedly[10] describes the pulmonary circulation. The following are literal translations of some of the passages in which he describes it.[11] ". . . Our purpose now is to set forth what we have been able to find of the discussions of the Sheikh, the Rais, Abi Ali al-Husein Ibn Abdallah Ibn Sina, on anatomy in his Canon, and that by collecting what he wrote in the first book of the Canon and the third book of the same, and so arrange properly all that he wrote on anatomy. What has deterred us from engaging in dissection is the authority of the law and our inherent compassion. So we see fit to depend, for the description of the internal organs, on the words of those who have preceded us—of those engaging in dissection —especially the honorable Galen, as his books are the best books that have come down to us on this subject. . . . We have relied chiefly . . . on his sayings, except in a few details which we thought might be mistakes of copyists or the fact that his description had not been given after a thorough observation. In describing the use of these organs we have depended on true observation and honest study, regardless of whether or not these fit the theories of those

(7) Sharḥ-ŭl-Hidayā f-it-Tībb, a commentary on Avicenna's Hidaya.

(8) Al-Mūjaz, a compendium on Avicenna's Canon.

(9) Sharḥ Qanūn Ibn Sīna, a commentary on Avicenna's Canon.

(10) Sharh Tashrih-il-Qanūn, a commentary on the Anatomy of the Canon.

[8] Risālat Fadil ibn Nātīq (The Epistle of Fadil Ibn Natiq) on Ar-Ragul-ŭl-Kāmil (The Perfect Man).

[9] This book has been mentioned by most of the Arab bibliographers. Brockelmann gives reference to four copies: Berlin No. 6272, Paris No. 2939, Bodleian II.178, and Escurial I.267.

We know of two other copies—one in the Zāhiri'yā Library, Damascus (No. 20), and the other in the private library of one of us obtained by purchase from Persia. We have had the opportunity to study and compare these two manuscripts and compare them with the Paris manuscript No. 2939. These three manuscripts are practically identical.

[10] This is repeated at least five times—in his description of the pulmonary vessels, of the heart, of the lung, of the portal circulation and liver, and of the brain.

Our attention was first called to this by Sarton. In his Introduction to the History of Science he credits Doctor Muhhy-id-Din At-Tatāwy of Cairo, as being the first to call attention to Ibn Nafīs's description of the pulmonary circulation. From personal communication with Doctor At-Tatawy we have learned that he made a translation into German from the Berlin copy and that only five typewritten copies were made. He also stated that he has turned over all his data to Doctor Meyerhof of Alexandria.

[11] In translating these passages we tried very hard to give as literal a translation of the original as possible—sometimes at the expense of good English. A literal translation of Arabic books is always difficult as a whole chapter is one continuous sentence. The photostatic reproductions are taken from our manuscript and they have been carefully checked with photostatic reproductions from the Damascus and the Paris copies.

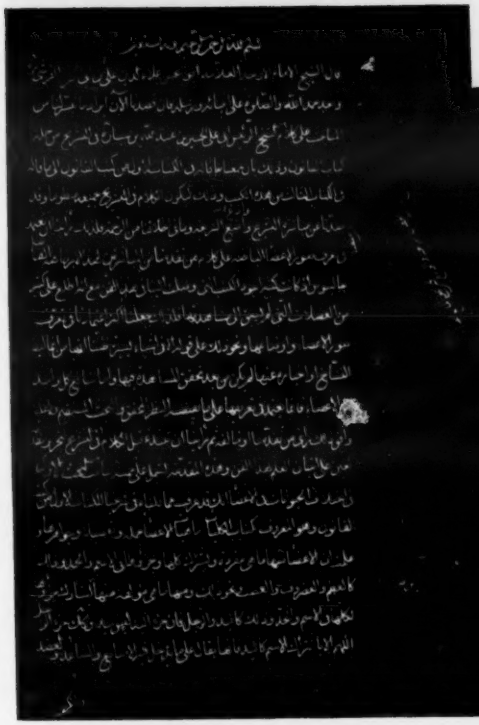

FIG. 1.—The introductory page of Ibn Nafis's Commentary on the Anatomy of the Canon.[11]

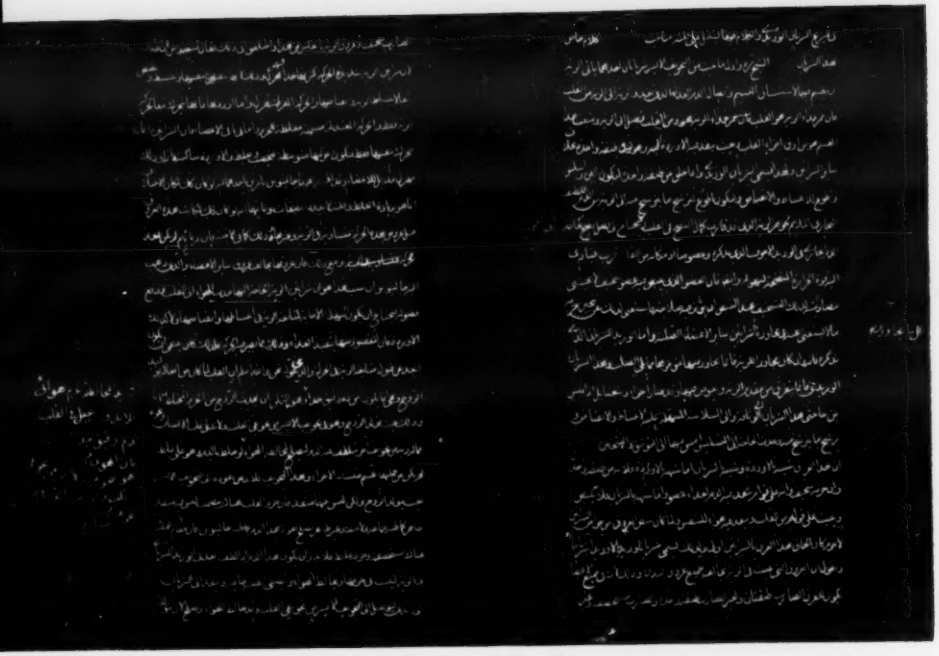

FIG. 2.—Description of the pulmonary vessels.

who have preceded us. . . . We see fit, before starting the discussion of anatomy, to write a preface that will help us to understand this science. The preface contains five discussions. The first is on the difference that animals show regarding their organs. . . ."

In describing the pulmonary vessels and their structure Ibn Nafīs disagrees with Galen and his predecessors as to the cause of the difference in structure between these vessels and the vessels in the other parts of the body. ". . . And we say, and God is the All-Knowing, whereas, one of the functions of the heart is the creation of the spirit from very thin blood strongly miscible with air, and air, so it is necessary to make, in the heart, very thin blood to make possible the creation of the spirit from that mixture. The place where the spirit is created is in the left cavity of the two cavities of the heart. Therefore, it is necessary, in the heart of man and his like—of those who have lungs—to have another cavity where the blood is thinned to become fit for mixing with the air. For if the air is mixed with the blood while it is still thick, it would not make a homogeneous mixture. This cavity (where the blood is thinned) is the right cavity of the two cavities of the heart. If the blood is thinned in this cavity it must of necessity pass to the left cavity where the spirit is created. *But between these two cavities there is no passage as that part of the heart is closed and has no apparent openings as some believed and no non-apparent opening fit for the passage of this blood as Galen believed.* The pores of the heart there are obliterated and its body is thick, and there is no doubt that the blood, when thinned, *passes in the vena arteriosa to the lung to permeate its substance and mingle with the air, its thinned part purified; and then passes in the arteria venosa to reach the left cavity of the two cavities of the heart; having mixed with the air and* become fit for the creation of the spirit. What is left of this mixture, less attenuated, the lung uses for its own nourishment. This is the reason why the vena arteriosa is made of thick walls and of two coats, so that what passes through its pores be very thin, and the arteria venosa thin and of one coat."

In describing the anatomy of the lung Ibn Nafīs states: "The lung is composed of parts one of which is the bronchi, the second the branches of the arteria venosa and the third the branches of the vena arteriosa, and all of these are connected by loose porous flesh. . . . *The need of the lung for the vena arteriosa is to transport to it the blood that has been thinned and warmed in the heart, so that what seeps through the pores of the branches of this vessel into the alveoli of the lung may mix with what there is of air therein and combine with it, the resultant composite becoming fit to be spirit when this mixing takes place in the left cavity of the heart. The mixture is carried to the left cavity by the arteria venosa.* What is left of that blood in the inside of the branches of the vena arteriosa and passes through its apertures to the body of the lung, would be thicker than the blood that seeps through and more watery, and fit for the nourishment of the lung. This vena arteriosa while it brings to the lung its nourishment, also brings the blood that is very thin and that is fit to become animal spirit when mixed with the air. The use of arteria

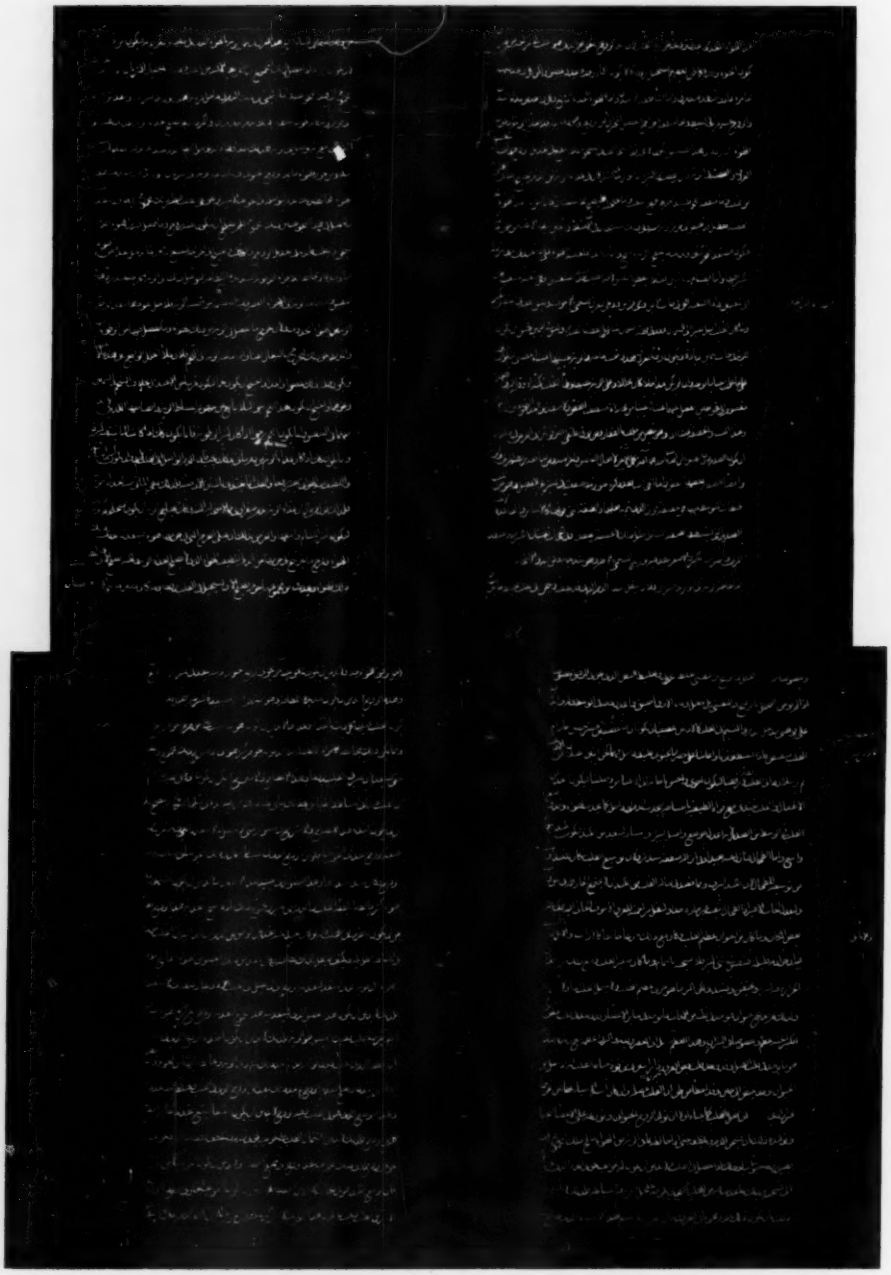

FIG. 3.—Description of the anatomy of the lung.
FIG. 4.—Description of the anatomy of the heart.

venosa is to transmit this air that is mixed with the thinned blood to the left cavity of the two cavities of the heart to become spirit. Another use is for the passage of what is left in this cavity of that mixture which was not fit for the creation of the spirit and of what is left in it of air that is overheated and useless. Both of these must come out of the cavity to make space for what comes afterwards of air alone or of air mixed with greatly thinned blood. So this vessel carries back these things to the lung to be discharged with the returning breath (expiration)."

In describing the anatomy and function of the heart Ibn Nafīs states further: ". . . The function of the heart, as we have shown, is first, the creation of animal spirit and its distribution to the organs in order to animate them. This creation comes about by heating the blood and making it thin so that when it is mixed with what there is of air in the lung, the mixture becomes fit for the production of the animal spirit. . . . *Therefore, for the nourishment of the spirit that is in the heart, it is necessary for the blood to become attenuated in the heart and its consistency very much thinned, then pass to the lung and mix with what there is of air there and be cooked in it until it is tempered and become fit for the nourishment of the spirit, and afterwards pass to the spirit that is in the heart and mix with it and nourish it.* . . . So of necessity the heart should have one cavity to contain the blood and thin it and another cavity to contain the spirit, and from this latter cavity the spirit passes to the different organs. And of necessity the cavity which contains the blood should be near the liver where the blood is made and so must be on the right side of the heart as the liver is on the right side of the body; and the cavity which contains the spirit on the left side of the heart. . . . And his (Avicenna's) statement that the heart has three ventricles . . . is not correct as the heart has only two ventricles, one filled with blood on the right side and the other filled with the spirit on the left side, *and between these two there is absolutely no opening for if there were, the blood would pass to the place of the spirit and spoil its essence. Also dissection gives the lie to what they said, as the septum between these two cavities is much thicker than elsewhere, lest some blood or spirit pass through and get lost.* . . . Again, his (Avicenna's) statement that the blood that is in the right side is to nourish the heart is not true at all, for the nourishment to the heart is from the blood that goes through the vessels that permeate the body of the heart. . . . *The benefit of this blood (that is in the right cavity) when it is thinned and attenuated is to go up to the lung, mix with what is in the lung of air, then pass through the arteria venosa to the left cavity of the two cavities of the heart and of that mixture is created the animal spirit.*"

SUMMARY

From the above literal translation of Ibn Nafī's description of the pulmonary circulation and from a careful study of his biography and books we can draw the following summary.

(1) He advises the study of comparative anatomy as an aid to the understanding of human anatomy.

(2) On several occasions he hints that he performed dissection—which was very rare among Moslem physicians—despite the fact that he denies this in his introduction. He mentions dissection as a basis for his claim.

(3) He was not a blind follower. He has his own convictions and after careful observation and recording he states these regardless of accepted authority.

(4) He classifies man as an air-breathing animal.

(5) He uses logic where observation does not suffice.

(6) He declares that blood is aerated in the lung and gives a definite description of the alveoli.

(7) He states that the heart is nourished by its own vessels.

(8) He gives a clear and definite description of the pulmonary circulation and repeats this more than five times in the text.

(9) Three manuscripts show clearly that Ibn Nafīs, a prominent Arab physician, gave a classic description of the pulmonary circulation in the thirteenth century.

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THE SURGICAL TREATMENT OF HYPERPARATHYROIDISM *

BASED ON 30 CASES CONFIRMED BY OPERATION

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THE ablation of parathyroid tissue is based upon the assumption that increased function is producing disease. In any particular case three lines of evidence test the soundness of this assumption.

(*a*) The demonstration of a disturbance in calcium and phosphorus metabolism is at the present time the only certain criterion upon which a diagnosis of hyperparathyroidism may be predicated. No other physiologic function has been indisputably linked with the parathyroids. If clinical experiments are undertaken in an effort to extend the indications for parathyroid surgery on the assumption that other functions may be ascribed to these glands, these efforts should be controlled by complete studies of the calcium and phosphorus metabolism.

(*b*) Removal of parathyroid tissue is followed by a change of the pathologic state toward normal. Certain manifestations of the disease may be of a nonreversible order (*e.g.*, bone cysts or renal calcification) but the change in metabolism following operation is striking and unmistakable.

(*c*) Definite structural changes in the parathyroid glands that may be correlated with the disturbance of function are a requisite finding in every case.

The cornerstone to successful surgery of the parathyroids is a positive diagnosis. An "exploratory operation" to confirm or disprove a doubtful diagnosis has little or no place in this field. The findings of the laboratory are more exact than the dissection of the surgeon, and there is no point in the operation at which the operator may lay down his scalpel and find comfort in having disproved the diagnosis. Even the demonstration of four normal parathyroid bodies is not adequate because there remains the possibility that a small adenoma of a fifth gland lies tucked away in some inaccessible region of the mediastinum. A positive diagnosis is therefore a challenge to the skill and patience of the surgeon and when these have been exhausted in a fruitless search for an adenoma, the operator is privileged to say, "the tumor cannot be found," but not, "the tumor does not exist."

Before undertaking an operation for hyperparathyroidism, the surgeon must be convinced of the correct diagnosis either through implicit confidence in his medical colleagues, or preferably by a first hand weighing of the evidence. The clinical aspects of the disease and the metabolic disturbances that accompany it have been discussed at length in many excellent articles on

* Prepared for the Xth Congress of the International Surgical Society.

the subject; the scope of the present paper is to consider certain aspects of the surgery of the parathyroids.

PARATHYROIDS AND RENAL STONE.—Renal calculus is very often the presenting clinical manifestation of the disease.[1,2] The recognition of this fact a few years ago has been largely responsible for the number of cases of hyperparathyroidism that comprise our series. The classic form of the disease presenting advanced skeletal changes is a rarity. As more attention is directed to early symptomatology particularly in the group of patients with renal involvement, it becomes apparent that hyperparathyroidism is not a medical curiosity but a disease of real significance and of not infrequent occurrence.

Two interesting problems have been presented by these cases of hyperparathyroidism in which renal complications have been the presenting symptom. The first arises from the reference to these cases as "hyperparathyroidism without bone disease." In point of fact, the designation should be "without bone disease demonstrable by roentgenography" until further bone biopsies have been studied in this group of patients.

The other problem is of more pressing clinical importance and will be solved only by increased experience. Given a patient with renal stone and hyperparathyroidism, which takes precedence in surgical therapeutics? The tendency at the moment is to regard the disturbance of parathyroid function as a chronic disorder of metabolism that can be handled in due time after the obvious problem of conserving kidney function has been settled. In many instances, as when a calculus is blocking a ureter, this is the correct sequence of procedures. On the other hand, many sequelae of renal surgery such as sepsis and temporary disturbance of renal function may be poorly tolerated or intensified in the face of severe hyperparathyroidism. These same sequelae of renal surgery may in turn make the proper handling of the hyperparathyroidism more difficult. The only answer that can be offered at the moment is that the urologist must consider the disease as a whole and not endanger the patient by myopic regional surgery. As a general rule the initial step in treatment will be the correction of the basic disturbance of metabolism.

Although the skeletal changes incident to hyperparathyroidism are crippling and painful, the real hazard of the disease is the damage suffered by the kidneys. Renal insufficiency or the complications of renal calculus have been the only causes of death in our cases.* Only a failure to grasp this fact can account for a revival of the treatment of hyperparathyroidism by dietary measures.[3] Dietary treatment was tried in early cases of our series[2,4] with, it is true, relief of certain symptoms and actual deposition of minerals in the bones. Two of these patients (Cases 4 and 6) died of renal complications two years and six weeks respectively following the removal of the parathyroid

* Three patients have died of the renal complications of hyperparathyroidism. Since the above statement was written one patient (Case 14) died of coronary occlusion two years after complete relief of his hyperparathyroidism by operation.

adenomata. We feel, therefore, that the treatment of hyperparathyroidism by a diet high in calcium and phosphorus is not only inadequate but positively dangerous.

THE NORMAL PARATHYROID.—The variation in size and shape of parathyroid bodies in normal individuals makes it impossible to offer anything but an approximate description of a so called "normal" gland. The typical size is 3 to 6 Mm. in length, 2 to 4 Mm. in width, and 0.5 to 2 Mm. in thickness. The average weight of a single gland in an adult is in the neighborhood of 0.030 Gm. In the gross, parathyroids are apt to be confused with small collections of fat, lymph nodes, or nodules of thyroid tissue. Parathyroid tissue tends to be softer than that of lymph nodes or thyroid but not as unorganized as fat.

Although a parathyroid body tends to conform in shape to immediately adjacent structures, an important clue to its identification lies in the fact that even in the gross a definite architecture is apparent. Lymph nodes and isolated nodules of thyroid tissue are rounded and plump. Normal parathyroids tend to be flattened, oftentimes with a sharply chiseled edge on one or more sides. Another clue to their identification is the small but definite vascular pedicle that enters at a miniature hilum. The shape as well as the characteristic brown color may be altered by a subcapsular hemorrhage which, because of the paucity of supporting stroma, follows even slight trauma.

The interpretation of the many types of cells that have been described as structural elements in normal parathyroid tissue must be left to the microscopic anatomists. It is possible that significant advances will be made in this field as additional material becomes available, that permits of the correlation of structure and function. We shall refer to four major cell types and certain transitional forms.

The *chief* or principal cell is polyhedral in shape and contains a sharply demarcated, large nucleus. The cytoplasm may be scant and is faintly acidophilic. The *"wasserhelle"* or "water-clear" cell is larger than the chief cell and shows complete vacuolization of the cytoplasm, a characteristic that may be present only as a peripheral halo in the chief cell. The nucleus is eccentrically located and hyperchromatic or even pyknotic. These cells are rare in the normal gland and are grouped in small clusters. The *pale oxyphil* cell is filled with uniformly acidophilic, finely granular cytoplasm without vacuolization. The nucleus is about the size of that of the chief cell but contains less abundant chromatin. The *dark oxyphil* cell is smaller than the pale oxyphil and contains a dark red homogeneous cytoplasm. The nucleus is small and pyknotic.

The number and distribution of these cells vary with age, and unless certain changes that occur normally with increasing age are recognized, they may be erroneously considered as pathologic. The most marked of these is the increase in pale oxyphil cells that begins at puberty. These increase in number and after 40 to 50 years of age form large islands that are sharply

circumscribed but not encapsulated. This is interpreted as an involutional change.

The stroma of the normal gland of an adult contains many large fat cells,

FIG. 1.—Longitudinal section of a normal parathyroid gland from an adult, aged 42 years, showing the paucity of supporting stroma and the proportion of fat cells to glandular elements (× 28).

FIG. 3.—Longitudinal section of a parathyroid gland from an adult, aged 80 years. Circumscribed islands of pale oxyphil cells are shown. These are interpreted as an involutional change with no known clinical significance (× 28).

the volume of these cells making up a very appreciable fraction of the total bulk of the gland. The replacement of fat cells by parenchymatous tissue is a striking element in pathologic changes, and one that is easily recognized in frozen sections.

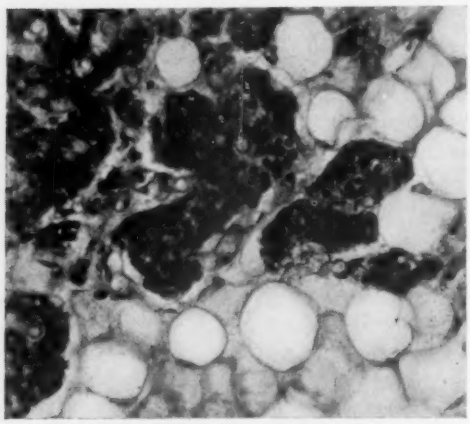

FIG. 2.—A higher magnification of a small portion of the gland shown in Fig. 1 showing normal chief cells and fat cells (× 350).

The finding of normal parathyroid bodies will always be difficult and may be impossible. The recognition of the glands when exposed should be precise and certain. There is no short cut by which the experience that leads to this precision can be achieved. Autopsy room dissections, with immediate checks by frozen sections while the visual image of the gross anatomy is fresh in the mind, are the first

steps in parathyroid surgery. In any operation the normal glands must be recognized when they are encountered and carefully preserved with their blood supply intact. *We know of no indication for the removal of a normal parathyroid body.* If doubt exists as to whether a gland is normal, biopsy with a sharp scalpel is permissible and the tissue may be immediately studied by frozen section.

Size and shape are not always obvious criteria for the recognition of pathologic changes, although usually enlargement is apparent in the gross and the characteristic chiseled edges of the normal gland are replaced by rounded contours. In Case 23 the right superior parathyroid appeared only slightly larger than normal although the other three glands were unmistakably enlarged (Fig. 10). All four showed typical "wasserhelle" cell hyperplasia of identical pattern. The size of a gland containing a small adenoma may be within the upper limits of normal variation. In Case 2 a right parathyroid body measuring 10 by 5 by 4 Mm. was removed which showed on section a well circumscribed, encapsulated adenoma making up about five-sixths of the specimen (Fig. 7). On one side there was a peripheral zone of normal parathyroid tissue. In this instance the plump, rounded contours of the gland gave the clue to the presence of the adenoma. Fortunately, the histopathology of the parathyroid bodies has been placed on a systematic basis[5] so that operative findings can be recorded by a clean-cut definition of the microscopic pathology rather than in terms of dimensions.

PATHOLOGY.—Two major types of pathologic findings occur in cases of hyperparathyroidism: (1) adenoma of a single gland or rarely of more than one gland (neoplasia), and (2) a uniform change of all glands (hyperplasia). At the present time we are unable to predict the type that will be found in the case of any individual patient on the basis of the preoperative data. It is imperative, however, that the two forms be differentiated at the operation if effective treatment is to be carried out. Castleman and Mallory[5] have published a detailed description of the pathologic findings in 25 cases of the Massachusetts General Hospital series. Their terminology will be followed in discussing the surgical significance of their findings. The reference to cases by number will be held identical with their designation as well as that in other publications dealing with the same patients.

HYPERPLASIA*.—The microscopic findings in all six cases described as diffuse hyperplasia are uniform and consistent. The glands are made up of large clear cells of the wasserhelle type showing a tendency to arrange themselves in acinar form. The cells vary from 10 to 40 microns in diameter,

* Generalized enlargement of the parathyroid glands has been described as secondary to longstanding renal insufficiency. It has been suggested that phosphorus retention induces a compensatory parathyroid enlargement. Bone changes may occur. As far as is known, this hyperplasia is of the chief cell type, differing from wasserhelle cell hyperplasia in microscopic section. Clinical data concerning this syndrome are fragmentary and the issue is confused by the fact that primary hyperparathyroidism may produce a secondary renal insufficiency. Surgical intervention would appear to be dangerous in case an enlargement of the parathyroids were really a compensatory mechanism.[5, 6]

averaging 15 to 20. The nuclei are all approximately the same size, averaging about 8 microns in diameter. As a rule the nuclei are located in the end of the cell that is contiguous to the stroma. This basal orientation of the nuclei produces a characteristic pattern in the low power field. Fat cells are practically absent in the stroma. No oxyphil or chief cells are found. There are no mitoses. The sections as observed with low magnification are strikingly similar to those from clear cell renal carcinomata.

A concept of parathyroid hyperplasia may be formulated by drawing a crude analogy with the thyroid gland. Case 26 showed by actual weight 11.20 Gm. of parathyroid tissue, and the weight of the residual tissue was estimated to be 0.225 Gm. This is a 95-fold increase over what may be called

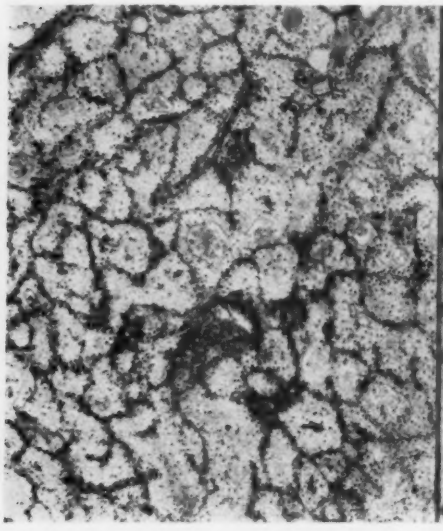

FIG. 4.—Wasserhelle cell hyperplasia. The basal orientation of the nuclei forms a characteristic pattern. There are no fat cells (× 78).

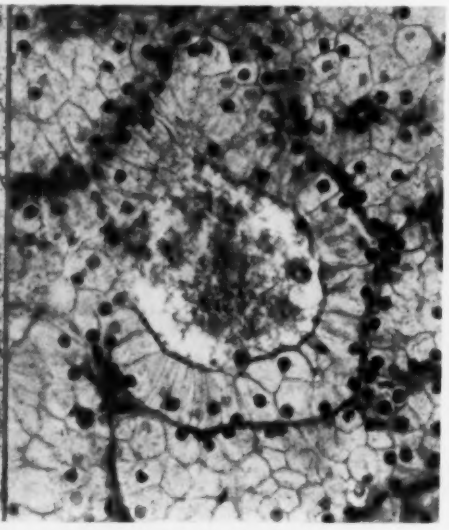

FIG. 5.—Wasserhelle cell hyperplasia. A higher magnification of a small field from the section shown in Fig. 4. Definite acinar arrangement of cells (× 350).

an average normal value (4 × .030 Gm.). Taking an average normal thyroid as weighing 23 Gm., hyperplasia of like magnitude would result in a goiter weighing 2,000 Gm. An exophthalmic goiter weighing 200 Gm. is an unusually large one, so the degree of hyperplasia determined by weight alone in this particular case was *ten times that found in a large exophthalmic goiter.* This computation does not take into account the fact that a considerable part of the weight of a normal parathyroid body is made up by inactive fat cells of the stroma. These are replaced by parenchymatous cells in hyperplasia. By similar computations, the largest adenoma in our series may be compared with an adenoma of the thyroid weighing 10 kilograms, or 22 pounds!

NEOPLASIA: *(Adenoma).*—Although the common type of pathologic change in hyperparathyroidism is the solitary adenoma, it will be stated again for emphasis that the pathology cannot be determined before the exposure of the glands at operation. The surgeon must therefore be prepared to adapt

his operative attack to meet the condition that is found. In four out of every five cases in our series this has been an adenoma of one gland.

In two instances among 24 cases of adenoma, tumors were found in two glands. This incidence of multiple tumors may be low as other glands were not inspected in many patients. On the other hand, the correction of the hyperparathyroidism by the operation in every instance of adenoma is presumptive evidence that other functioning tumors did not exist.

Adenomata are usually easily recognized in the gross. They are not only larger, but show a departure from the architecture of the normal gland. A

FIG. 6.—Longitudinal section of a parathyroid gland showing a small adenoma as an incidental autopsy finding. The sharply circumscribed and encapsulated adenoma encroaches upon normal gland parenchyma (× 28).

FIG. 7.—Parathyroid adenoma removed from Case 2. A narrow fringe of normal parathyroid tissue is shown at one pole of the adenoma.

frozen section is invariably made at the time of operation as the only certain means of differentiation from hyperplasia.

The size of adenomata is subject to wide variation. Castleman and Mallory have drawn a rough correlation between the size of the tumor and the degree of hypercalcemia, but other variables such as the duration of the disease are so significant that definite conclusions are unwarranted. Also the degree of hypercalcemia as observed clinically cannot be correlated with the skeletal decalcification or with the severity of clinical manifestations.

Histologically, the adenomata show a wide variation in cell type. The elaborate classification of Castleman and Mallory will not be repeated or reviewed in this paper; their conclusions, however, may be stated briefly. In the single tumors the chief cell with its transitional forms accounts for at least 90 per cent of the specimens. Pure tumors of either the oxyphil or wasserhelle type unaccompanied by chief cell forms have not been encountered in our series, although cells of either of these types may be predominant. In other words, the chief cell is the only invariable component of a tumor, and from this observation it is deduced that it is the basic fundamental cell and possibly the only proliferative form. The other cell types derived from it are interpreted as degrees of differentiation or as involution forms.

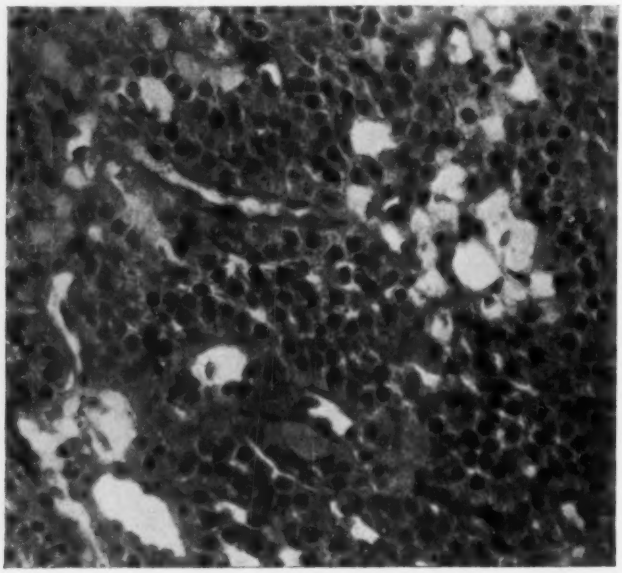

FIG. 8.—Chief cell type of adenoma from Case 9 (× 350).

OPERATIVE TECHNIC.—The operation as we have previously described it is a meticulous dissection of the structures of the neck lying anterior to the prevertebral fascia. Attention is first directed to securing an adequate exposure of the thyroid gland by complete transverse section of the sternothyroid and sternohyoid muscles. Usually the omohyoid muscles are divided. The contours of the thyroid gland are studied, as a large tumor lying posteriorly may thrust one of its lobes forward. If no clue exists as to the location of the tumor, either side may be chosen for the beginning of the dissection. A traction suture is fixed in the anterolateral position of one lobe of the thyroid and the gland turned forward after ligation and section of the lateral thyroid vein. Dissection is carried posteriorly until the recurrent nerve is exposed at the point where it crosses the inferior thyroid artery. If no gross tumor has been exposed up to this point it is well to turn to the

other side and carry the dissection to the same point. From now on the conduct of the operation must be left to the resources of the individual operator. The posterior surfaces of the thyroid gland must be searched with painstaking care for normal or enlarged parathyroid bodies. When normal glands are exposed the field of search is correspondingly narrowed by exclusion. Our experience has in general confirmed the observation of Walton[7] that tumors of the superior parathyroids may be found in the posterior mediastinum and tumors of the inferior parathyroids in the anterior mediastinum. These mediastinal tumors appear to reach this aberrant position in one of two ways, either by growth of an adenoma in a gland developmentally located in the mediastinum, or by the descent of a tumor into the mediastinum after growth in the neck. The neck should be thoroughly searched before the mediastinum is explored, as the finding of normal glands may indicate by exclusion the regions that are to be investigated first.

Splitting of the sternum to afford a direct visual approach to the anterior mediastinum is a procedure that will rarely be required. Since this was done in Case 6, we have removed two equally inaccessible tumors by digital manipulation from above. Both of these tumors were situated anterior to the great vessels at the level of the second intercostal space. They were found only by careful digital exploration, as no clue to their position was found in the neck dissection. Tumors in the posterior mediastinum in our experience have been less difficult to find than those in the anterior mediastinum as their upper end is apt to be anchored in the region of the inferior thyroid artery. When a thorough dissection has been carried out and no tumor found it is most apt to be located in the anterior mediastinum.

When a definite adenoma is disclosed early in the operation, how extensive a search should be made for a second tumor? In seeking an answer to this question we assume that a frozen section has been examined by the pathologist and generalized hyperplasia excluded. Adenomata of two parathyroid bodies have been found in two of our 30 cases of hyperparathyroidism. In one of these (Case 20) biopsies from both remaining parathyroids showed normal tissue, and in the other (Case 21) the remaining parathyroids could not be demonstrated even by resection of the lobe of the thyroid on that side. The incidence of multiple tumors in our series is therefore two in 30 or 6.6 per cent. Despite this appreciable incidence of multiple tumors, our procedure at the moment would be to stop the dissection when a definite adenoma is found, after being assured that no second tumor of large size and easy accessibility is present. If the operation is extended to rule out the presence of a second tumor, it must be carried to the extent of exposing all of the remaining parathyroids. A half-hearted search is worse than none at all because it leaves a legacy of scar tissue without achieving its purpose; namely, that of excluding a second tumor. The presence of a second adenoma will be disclosed by the postoperative trend of the blood chemistry, and if present it may be more readily found at a second operation if a relatively virginal operative field is left.

We have not personally encountered a parathyroid tumor or a normal gland lying entirely within the substance of the thyroid gland. We have observed an hyperplastic gland so deeply buried in a sulcus of the thyroid that it was found only by resection of that portion of the lobe of the thyroid gland. On careful dissection it was demonstrated that its position was outside of the true capsule of the thyroid and a small portion of it actually presented on the surface of the gland. However, normal glands as well as adenomata have been described completely buried within the substance of the thyroid, and it may be necessary to sacrifice a lobe or a portion of a lobe of that organ. Palpation of the thyroid may reveal a suspicious nodule, or the identification of normal parathyroid bodies may, by exclusion, point to the lobe or the portion of the lobe that is to be resected.

The coexistence of a nodular goiter makes the search for parathyroids very difficult. In several instances a tumor that was palpable before operation turned out to be a nodule of thyroid tissue. In only two of our cases was the parathyroid adenoma itself palpable prior to operation.

Operation in Hyperplasia.—In a previous article[8] we stated that "Diffuse hyperplasia of the parathyroids associated with hyperparathyroidism—in other words, a state of affairs analogous to Grave's disease of the thyroid—has not as yet been recognized as a disease entity." Since the above statement was made we have personally encountered six cases that appear to fall into that category. The first three of these cases have already been reported in full.[9,10] In Case 15 two hyperplastic parathyroids were removed at the first operation, and a subtotal resection of a very large third gland carried out subsequently. A fourth gland could not be found. This patient shows a tendency to maintain more nearly normal calcium and phosphorus blood values than before operation, but obviously her disease has not been adequately corrected and she still has a mild hyperparathyroidism. As she is an elderly and frail individual, further surgery is not contemplated.

In Case 16 two enlarged glands were exposed on the right side and both were removed. This patient has had no further symptoms and the blood calcium level is normal. A continued low serum phosphorus suggests that mild hyperparathyroidism may be present. The actual weight of hyperplastic tissue removed from this patient was 15.6 Gm. (in terms of thyroid hyperplasia, a 3,000 Gm. goiter!). Assuming that the remaining two glands were hyperplastic, it is probable that they are small in size.

Case 17 was the first case of hyperplasia in which the true nature of the pathology was recognized at operation, and marked the beginning of the adequate surgical treatment of this condition. Four hyperplastic glands were exposed surgically; three of them and a small portion of the fourth were removed. This patient did not develop tetany and the blood levels of calcium and phosphorus have been maintained at a normal level. In all, 3.4 Gm. of hyperplastic tissue were removed from this patient.

The other three cases of generalized hyperplasia will be described in some detail as the evidence afforded by them extends our knowledge concerning

adequate surgical treatment of this form of hyperparathyroidism. These cases have already been reported briefly.[11,12]

Case 23.—A. S., a telephone lineman, aged 41, entered the hospital February 6, 1934.[11] Six months previously, following attacks of left renal colic, several stones were removed from the urinary bladder by cystoscopy. He continued to have pain in the left flank and sacro-iliac region. Two months later a tonsillectomy was performed and this was followed within a week by an attack of generalized pain and tenderness throughout the entire body, particularly radiating down both legs. Recovery was slow and the dull aching pain remained localized in the left hip and sacro-iliac region. This pain was aggravated by walking and standing. He lost 35 pounds in weight. Examination was negative except for tenderness in the region of the left sacro-iliac joint and some limitation of extreme flexion and hyperextension of the spine. There was also tenderness over the bladder and over the course of the left spermatic cord. Roentgenologic examination revealed a honeycombed area of bone destruction in the central and superior portion of the left ilium. This area had the appearance of a multiloculated cystic tumor with sharply defined dense margins. The defect was approximately 6 cm. in diameter. This area was later (February 20, 1934) excised from the ilium and proved on careful pathologic examination to be an atypical chondrosarcoma. The microscopic findings in no way resembled the classic types of bone pathology known to be associated with parathyroid disease. Complete studies on the patient showed a constantly elevated serum calcium and a slightly low serum phosphorus (Table I).

TABLE I

CASE 23

Date	Calcium mg./100 cc.	Phosphorus mg./100 cc.
February 10, 1934	13.1	2.92
February 15, 1934	12.67	2.58
March 19, 1934	12.8	2.66
July 7, 1934	13.2	3.04
July 9, 1934	....	2.48
July 12, 1934	Parathyroidectomy	
July 13, 1934	10.1	2.80
July 14, 1934	9.9	2.90
July 16, 1934	9.1	3.36
July 21, 1934	11.3	3.84
July 27, 1934	10.2	3.40
August 2, 1934	11.1	3.32
October 19, 1934	11.8	3.45
April 12, 1935	9.9	3.18

Roentgenologic examination of the entire skeleton showed a mild degree of osteoporosis in the bones of the lower extremities, the pelvis and vertebrae. Roentgenograms of the urinary tract showed a calculus in the lower calyx of the left kidney. The phosphatase was 6.1 Bodansky units. Renal function was normal and the nonprotein nitrogen 35 mg. Several examinations confirmed the presence of a small amount of Bence-Jones protein in the urine. (This has been found in a few other cases of hyperparathyroidism in this series and a diagnosis of multiple myeloma considered but excluded.) The patient was discharged and returned in July, 1934, still complaining of bone and muscular pains. Further studies having confirmed the diagnosis of hyperparathyroidism, he was operated upon on July 12, 1934. The right inferior parathyroid body weighed 0.13 Gm. and measured 8 by 6 by 3 Mm. The left superior parathyroid weighed 2.18 Gm. and measured 3 by 1.7 by 0.8 cm. The left inferior parathyroid weighed 0.16 Gm. and measured

1.1 by 0.6 by 0.3 cm. These three glands were removed in their entirety. The right superior parathyroid measured 7 by 4 Mm. and a small portion was removed for biopsy. The cells throughout all specimens were found to be of the large wasserhelle type with a definite glandular arrangement. The appearance was similar to that of the other cases of hyperplasia. The patient showed no symptoms or signs of tetany. The preoperative and postoperative blood chemistry findings are recorded in Table I. There has been considerable improvement in strength and the pain and tenderness of the left hip region

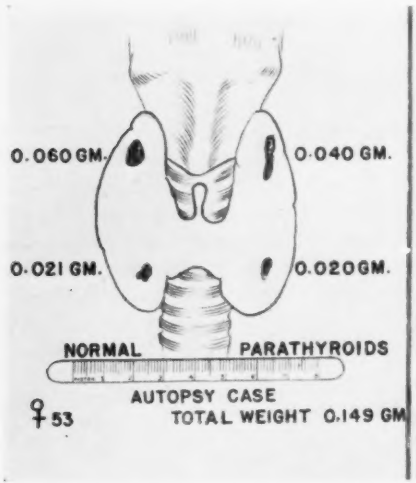

FIG. 9.—Four normal parathyroids were removed at autopsy and photographed on a diagram of the thyroid gland. The same diagram is used in Figs. 10, 11 and 12 to display surgical specimens of hyperplasia.

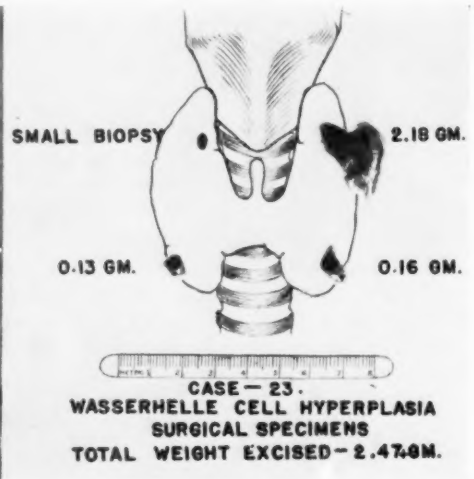

FIG. 10.—Surgical specimens from Case 23 photographed on the same diagram used in Fig. 9. The right superior gland is blocked in accordance with measurements made at operation.

has been largely relieved although the scar over the ilium is still tender. When last seen he was able to return to work.

Case 25.—W. P., a chauffeur, aged 39, had enjoyed good health until two years prior to his admission to the hospital on October 4, 1934.[12] At that time he first noticed increasing thirst and generalized weakness. He began to have typical attacks of right renal colic. Roentgenologic examination confirmed the presence of a stone blocking the right ureter, which was removed October 6. Renal function tests showed normal excretion. Chemical studies that are routinely carried out on all renal stone cases showed findings consistent with hyperparathyroidism (Table II).

TABLE II

CASE 25

Date	Calcium mg./100 cc.	Phosphorus mg./100 cc.	Phosphatase
October 5, 1934	12.17	2.58	....
October 8, 1934	11.30	2.35	....
October 24, 1934	13.91	2.96	3.67
October 27, 1934		Parathyroidectomy	
October 29, 1934	9.43	1.34	3.87
November 5, 1934	9.19	3.32	....
November 21, 1934	8.82	3.20	....
December 19, 1934	8.58	3.16	....
February 27, 1935	11.63	2.96	3.68
March 13, 1935	9.74	3.24	....

Roentgenograms of the skeleton showed no variation from normal and the phosphatase was 3.6 units (4 units=normal). A careful check of the blood values confirmed the diagnosis. Operation for hyperparathyroidism was performed October 27, 1935. The thyroid gland was symmetrical and normal, and a biopsy showed normal microscopic findings. A biopsy of the tibia taken at the time of operation showed microscopically normal bone. On the right side an enlarged superior parathyroid body was easily exposed. Hyperplasia was strongly suggested by the gross appearance of this gland as it was more irregular and darker brown than the usual adenoma. A frozen section

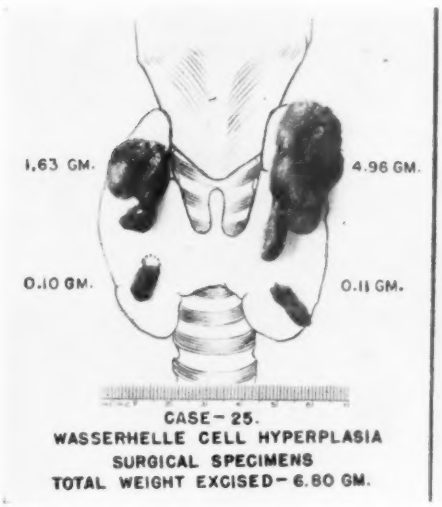

FIG. 11.—Surgical specimens from Case 25 photographed on diagram. The dotted line adjacent to the right inferior gland outlines the portion of parathyroid tissue not removed. See Table III for summary of weights.

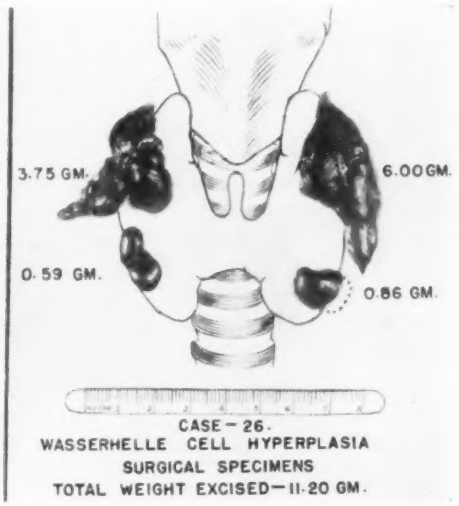

FIG. 12.—Surgical specimens from Case 26 photographed on diagram. The dotted line adjacent to the left inferior gland outlines the portion of parathyroid tissue not removed. See Table V for summary of weights.

confirmed the diagnosis of wasserhelle cell hyperplasia. Two other enlarged glands were readily found but a prolonged search was required to locate the left inferior parathyroid. It was ultimately found only by resecting the lower two-thirds of the left lobe of the thyroid. By transverse section of this part of the thyroid an enlarged parathyroid was found deeply embedded in a sulcus. In addition to this left inferior gland, both superior parathyroids were totally removed. Approximately three-fourths of the right inferior parathyroid body was then resected, leaving a modicum of tissue measuring 7 by 4 by 3.5 Mm. of estimated weight approximately 0.040 Gm. (Fig. 11). The table of weights is shown in Table III.

TABLE III

CASE 25

Weight of parathyroid tissue excised		
Left upper	4.96	Gm.
Right upper	1.63	Gm.
Left lower	0.11	Gm.
Right lower (subtotal)	0.10	Gm.
Total excised	6.80	Gm.
Weight (estimated) tissue not excised.		
Right lower	0.040	Gm.
Ratio remaining to amount excised 4/680 or 1/170		

Microscopic examination showed the cells of all the specimens to be of the large wasserhelle type, some with a tendency to acinar arrangement. These findings were taken to be characteristic of hyperplasia. The patient showed transient tetany. The course of his postoperative blood chemistry is recorded in Table II, and he has remained well to date.

Case 26.—A. T., a housewife, aged 57, was admitted on January 21, 1935.[12] Following three attacks of renal colic, she passed a urinary calculus in March, 1931. One month later her right kidney was removed elsewhere. In the summer of 1934 she experienced almost daily attacks of dull pain in the left lower back radiating at times to the groin. During the six months prior to admission she had vague aches and pains throughout her body. In the spring of 1934 her weight was approximately 98 pounds; on admission it was 83 pounds. Her appetite was poor and she complained of fatigue on exertion, increasing during the preceding six months. Roentgenograms showed generalized skeletal decalcification with several areas of diminished density in the skull that suggested multiple myeloma. Blood chemistry studies are shown in Table IV. A bone biopsy showed the changes characteristic of hyperparathyroidism. Renal function tests showed normal excretion by the remaining kidney. Blood pressure was 90/60.

TABLE IV

CASE 26

Date	Calcium mg./100 cc.	Phosphorus mg./100 cc.	Phosphatase
January 17, 1935	14.46	2.00	....
January 25, 1935	15.62	2.49	....
February 6, 1935	16.38	2.66	....
February 8, 1935	.....	2.91	4.84
February 9, 1935		Parathyroidectomy	
February 11, 1935	11.06	2.21	....
March 9, 1935	11.8	3.11	2.56
April 16, 1935	10.24	3.66	....
May 16, 1935	9.35	3.43	4.32

On February 9, 1935, an operation was performed with the diagnosis of hyperparathyroidism. All four parathyroids were exposed (Fig. 12). Their weights are recorded in Table V. Both superior glands and the right inferior were removed. Approximately three-fourths of the left inferior parathyroid was resected leaving residual tissue estimated at 0.225 mg. with a good blood supply. The pathologic diagnosis was generalized hyperplasia of wasserhelle cell type.

TABLE V

Weight of parathyroid tissue excised	
Left upper	6.00 Gm.
Right upper	3.75 Gm.
Left lower (subtotal)	0.86 Gm.
Right lower	0.59 Gm.
Total excised	11.20 Gm.
Weight (estimated) tissue not excised	
Left lower	.225 Gm.
Ratio remaining to amount excised .225/11.20 or 1/49.	

This patient has shown a marked improvement, gaining weight and strength. Her skeletal pains have gradually disappeared and the blood levels of calcium and phosphorus remain within normal limits. There was no tetany.

Assuming that the renal calculus episode in 1931 was a manifestation of hyperparathyroidism, the duration of generalized hyperplasia in this patient was at least four years. Certain cases of adenoma have, of course, been of much longer duration.

SECONDARY OPERATIONS.—In five instances we have been called upon to operate upon patients in whom the hyperparathyroidism had not been corrected by one or more operations in other hands. These all proved to be cases of adenoma in which the tumor had not been found at the previous operations.

TABLE VI

SECONDARY OPERATIONS

Case	Previous Operations	Position and Size of Tumor
4	(1) September 12, 1930. Two normal parathyroids and a nodule of thymus resected.	September 28, 1932. Retro-esophageal adenoma 3.5 by 2 by 1 cm.
6	(1) May 17, 1926. Normal parathyroid (right) resected. (2) June 11, 1926. Normal parathyroid (left) resected. (3) March 9, 1932 (New York City). Right lobe of thyroid resected. (4) June 27, 1932 (by authors). Left lobe of thyroid resected. (5) July 26, 1932 (by authors). Block dissection of right anterior triangle. (6) October 5, 1932 (by authors). Block dissection of left anterior triangle.	November 2, 1932. Anterior mediastinal adenoma 4 by 2.5 by 2.5 cm. Removed by splitting upper portion of sternum.
7	(1) October 19, 1931 (Worcester, Mass.). Aberrant lobe of thyroid resected. (2) May 6, 1932 (Worcester, Mass.). Major portion right lobe of thyroid and a nodule of thymus resected. Paralysis of right vocal cord.	November 15, 1932. Anterior mediastinal adenoma 3.5 by 2 by 1.5 cm.
27	(1) December 27, 1934 (Hartford, Conn.). No parathyroid tissue identified.	April 12, 1935. Adenoma posterior to right lobe of thyroid 2.6 by 1.8 by 1 cm. Subtotal resection of 3.06 Gm.
28	(1) June 27, 1934 (Madison, Wis.). "Intracapsular parathyroid tumor" removed. (Not confirmed by microscopic sections submitted.) Right lobe of thyroid removed. Two normal parathyroids identified on left. (2) December, 1934 (Iowa City, Iowa). Several pieces of tissue removed but no parathyroid tissue identified. Exploration carried "well down into upper mediastinum."	June 13, 1935. Anterior mediastinal adenoma. Subtotal resection of 11.8 Gm.

It will be seen from the table that an unusual position of the tumor is the chief cause of failure to locate it. It will also be seen that the removal of normal glands not only is without effect on the disease, but seriously complicates the situation when the tumor is found. Routine examination of the larynx is made before and after every operation, but is particularly important before a secondary procedure is contemplated. In Case 7 the right recurrent nerve had been paralyzed at one of the two previous operations, a situation

that warned one to use the most meticulous care in the dissection of the opposite side.

In a secondary operation it is our custom to define the carotid sheaths and approach the deeper regions of the neck just medial to these structures. The immediate neighborhood of the thyroid gland is disregarded if scar tissue indicates that there has been a dissection of the region. The retro-esophageal space is exposed, and also the plane between the esophagus and trachea. The search is then carried to the mediastinum, particularly its anterior portion.

Postoperative Hypoparathyroidism.—A major problem in the surgery of hyperparathyroidism concerns the amount of tissue to be resected and the deliberate division of the operation into stages to minimize its hazards. In this matter, as in the surgery of exophthalmic goiter, the surgeon must be guided by a knowledge of the fundamental nature of the disease and a careful appraisal of the individual patient. The pathologic condition disclosed at operation is also a determinant. Of particular importance is a clear understanding of the etiology of postoperative tetany.

The danger of tetany is by no means obviated by leaving intact parathyroid tissue. In fact, severe and life-endangering tetany has been observed when a generous portion of an adenoma was left in addition to the other three presumably normal glands. Even mild postoperative tetany may be distressing to the patient, and severe tetany is not only distressing but constitutes a hazard to life. The patient suffers from paresthesias and painful muscular spasms. The dangers of laryngeal spasm are well known. The mental disturbances are apt to be alarming. A profound depression may ensue, marked by a fear of impending disaster. In one patient this led to a distinct personality change bordering on a definite psychosis. Mild cases usually clear up in a few days, but the severer forms have been prolonged for a period of two to three months. The circumstances under which a sudden reduction in the amount of parathyroid tissue may lead to profound tetany are becoming more and more apparent through experience. The problem is obviously not so simple as that of the tetania parathyropriva encountered as a complication of goiter surgery.

There is adequate basis for differentiating two types of tetany that may occur following the removal of parathyroid tissue; the *tetany of true hypoparathyroidism* and the *tetany of the recalcification period*. A third and unproven hypothesis will be briefly mentioned.

Tetany of Hypoparathyroidism.—The simplest type of tetany is found in the hypoparathyroidism that follows the ablation of parathyroid tissue to the extent that an insufficient amount remains to meet the normal requirements of the body. This form of tetany may be considered as independent of any bone disease, although if the latter is present it may be expected to alter the clinical picture especially in the immediate postoperative period. This is the type of tetany that is encountered from time to time in goiter surgery. It has occurred only once in this series of parathyroid operations.

Tetany of the Recalcification Period.—The term tetania parathyropriva

is reserved for cases in which there remains insufficient parathyroid tissue to maintain a normal level of calcium in the normal body. In hyperparathyroidism the body may be far from normal due to the depletion of the lime salts of the skeleton. Following the ablation of parathyroid tissue severe tetany then results from the abnormal demand of the bones for calcium. When this demand ceases with completed recalcification, parathyroid function is found to be normal. In case a partial resection of an adenoma is carried out to lessen the severity of this form of tetany, a mild degree of hyperparathyroidism may actually reassert itself.

This type of tetany appears similar to that encountered in rickets when a flow of calcium into a depleted skeleton is initiated by the administration of vitamin D or by sunlight.

There are two elements implicated in the production of the tetany of the recalcification period; the existing decalcification of the skeleton, and the number of osteoblasts that are ready to promote recalcification. With reference to the first element the bones may be termed "empty," while the latter indicates that the bones are also "hungry." When the disease is corrected and the flow of minerals into the bones is rapid as a result of the combined action of these two elements, the blood level of calcium falls to a tetanic level and remains there. Even a greatly increased dietary intake may be inadequate to compensate for this demand of the bones and large amounts of calcium must be provided by other routes. Only when the demand of the bones has been satisfied does the blood level of calcium return to normal.

The behavior of the phosphorus levels is also of interest. In the tetania parathyropriva of goiter surgery the phosphorus blood level rises above normal. In the tetany of the recalcification period the phosphorus tends to remain low or has even been observed to drop still further. Recovery from the period of tetany may be heralded by a rising blood phosphorus. This drop in serum phosphorus immediately following removal of parathyroid tissue has also been observed in five patients in whom no severe tetany occurred. Its full significance is not as yet apparent.

The degree of decalcification of the bones may or may not be adequately shown in the roentgenograms. An index of the osteoblastic activity is clearly afforded by the level of phosphatase in the blood serum. The enzyme phosphatase plays an important rôle in the deposition of calcium phosphate in osteogenesis. In diseases attended by active bone destruction and regeneration the amount of this enzyme in the blood is increased. Of the nine patients in this series showing preoperative phosphatase levels of more than 14 Bodansky units (four being considered as the upper limit of normal), five had severe postoperative tetany. In three of these this occurred in spite of what was considered a conservative partial resection of an adenoma.

Two of the four patients with high phosphatase levels who did not have severe tetany were operated upon after we realized the probable significance of the high serum phosphatase and a partial resection of an adenoma was done with this in view. The remaining two with high phosphatase levels and

with but transient tetany (Cases 8 and 24) both had lesions resembling Paget's disease roentgenologically, and therefore the high level may well have been due to a coincident Paget's disease.

The preoperative level of the serum calcium cannot be taken as an indication of predisposition to tetany. The serum calcium level starts to fall almost immediately after the operation and if severe tetany is to occur, the first signs become manifest within 48 hours. The level of the serum calcium at which these first signs of tetany appear varies considerably from a level well above normal values in certain instances to a level half that of normal in others.

The preoperative level of the serum phosphorus if characteristically below normal gives no indication of the tetany that may follow operation. A serum phosphorus level approaching normal values, however, is usually indicative of advanced renal damage and under these conditions severe tetany has been encountered. Tetany occurring in the presence of an already established acidosis secondary to renal insufficiency is difficult to control as it will be recalled that one of the most effective measures in the treatment of tetany is the production of acidosis.

Tetany by Inhibition of Function.—An entirely different hypothesis which may play a rôle, particularly in transient tetany, has to do with the physiologic inhibition of the activity of the normal glands by prolonged hypersecretion from an adenoma. There is some evidence that this occurs, but it is impossible to evaluate its significance without a quantitative test for circulating parathormone. The whole problem may well be elucidated when methods of determining both the calcium and phosphorus partitions of the blood are perfected and directed toward clinical problems.

Radical and Conservative Operations.—When all parathyroids are involved in generalized hyperplasia of the wasserhelle cell type a subtotal resection is indicated. The usual anatomic separation of parathyroid tissue into four units must not obscure the concept of the entire system as a single organ. To correct satisfactorily the state of hyperfunction it may be advisable to resect three glands and a liberal portion of the fourth. Estimates of the weight of residual tissue in comparison with that resected are given in the case reports.

In the case of a single adenoma the ideal procedure is a complete removal of the entire tumor. When severe tetany may be expected, as outlined above, this may be dangerous and a conservative course of partial resection should be followed. A wedge-shaped portion is removed and the gland reconstructed by fine silk stitches in its capsule. When residual tissue is left in this manner it is placed with its blood supply intact in a position where it may readily be found if a second operation proves necessary. This should be at a distance from the laryngeal nerves.

Radical and conservative measures in parathyroid surgery are therefore measured first by the extent of the subtotal resection of the entire system of

glands in hyperplasia, and secondly, by total or partial resection respectively of a single adenoma.

The catastrophe of removing all parathyroid tissue either by deliberate resection or unwitting damage to its blood supply can be avoided by careful surgery. The possibility is encountered as a real hazard in secondary operations when normal parathyroids have been actually removed or their integrity jeopardized at a previous operation. We have always done a partial resection of an adenoma under these circumstances.

We have not infrequently removed a single adenoma in its entirety without extending the dissection to demonstrate other parathyroid tissue. In Case 21, however, two adenomata were exposed and a careful search failed to reveal the other glands. Under such conditions a portion of one of them was left *in situ*. Evidence that fewer than four parathyroids may be a normal anatomic condition is always open to question as a negative finding, while evidence of the occurrence of supernumerary glands is positive and conclusive. The fact must be kept in mind, however, that even the most painstaking autopsy dissections frequently yield only two or three glands. It is possible, therefore, that the removal of even two parathyroids may be hazardous if remaining glands cannot be demonstrated. Certainly in any case of doubt, a second operation for the removal of more tissue is to be preferred to taking any risk of depriving a patient of all parathyroid tissue.

Sepsis either within the urinary tract or elsewhere appears to increase the severity of tetany and to make its treatment more difficult. Its presence therefore points the way toward less radical surgery (Fig. 13).

The indications, therefore, for conservative surgery in an effort to avoid the complications of severe postoperative tetany may be summarized as follows:

(1) A high plasma phosphatase (14 or more Bodansky units) associated with decalcification of the skeleton. The extent of the latter may not be appreciated from roentgenologic studies.

(2) Sepsis or general debility.

(3) Renal impairment.

(4) Unknown status of normal parathyroids as in a secondary operation.

(5) Unknown status of other parathyroids when dealing with multiple adenomata.

ILLUSTRATIVE CASE HISTORIES

Tetania Parathyropriva.—Only one patient in this series developed true hypoparathyroidism. Two normal parathyroids had been removed at a previous operation and in doing a partial resection of the adenoma an insufficient amount of tissue was left.

The disease in Case 4 was of the classic type with a story of weakness and bone pains of several years' duration. Skeletal disease produced multiple fractures prior to the first operation in 1930. Three kidney stones were demonstrable in the roentgenogram. During the subsequent two years she was kept under observation by Doctor Albright

and the effects of a high calcium diet studied. There was an actual deposition of lime salts in the bones with partial relief of her symptoms, but early signs of renal impairment also made their appearance during this period. This happening was an important link in the story of renal complications of hyperparathyroidism.[2]

This patient was the first recorded case of partial resection of a parathyroid adenoma. The tumor was found at operation in 1932. It was definitely known that two normal parathyroids had been removed in 1930. No trace could be found of a fourth gland which might well have been destroyed at the previous operation. In planning a partial resection there was no precedent upon which to estimate the secretory activity of residual adenomatous tissue. A piece of tissue twice the size of a normal gland was left. If confronted with this problem at the present time, in view of our experience with this

A B

FIG. 13.—(A)—Case 27 on admission. Fractures of both femurs, ischiorectal abscess, decubital ulcers and advanced cachexia. Indication for partial resection of an adenoma. (B)—Six months after partial resection of a parathyroid adenoma. Gain of 42½ pounds in weight, ulcers healed, fractures uniting.

and subsequent cases, a less radical operation would be done. The amount that was left proved eventually to be just insufficient to maintain normal parathyroid function.

It is unfortunate that the records lack a determination of the phosphatase level in 1930. By all other criteria she had active bone disease at that time and it is probable that the phosphatase was elevated. In 1932, the phosphatase level was but 7.5 units, only twice the expected normal. This, it will be recalled, was after considerable recalcification of her skeleton by the high calcium diet. Two days after partial resection of the adenoma the phosphatase was only 5 units, but slightly above normal. Three days after operation mild tetany was apparent. By the thirteenth day this had developed into tetany of moderate severity with carpopedal spasm and respiratory difficulty which was promptly controlled with calcium chloride. She left the hospital less than a month after the operation with the latent hypoparathyroidism well controlled by calcium medication.

Table VII records the blood levels of calcium, phosphorus, and phosphatase during the entire time she was under observation. It is of interest to note the low level reached by the serum calcium before true tetany was observed. It is also of interest that the serum phosphorus rapidly increased after operation to a high normal level. This is the characteristic finding in the tetania parathyropriva of goiter surgery—a low calcium but a high phosphorus—and should be distinguished from a high preoperative blood phosphorus which in certain cases has been associated with renal impairment. Before operation the serum phosphorus was low and although minimal signs of impaired renal function had appeared, the kidney function was apparently adequate in regard to phosphorus.

TABLE VII

CASE 4

UNCOMPLICATED HYPOPARATHYROIDISM

Date	Serum Calcium	Serum Phosphorus	Serum Phosphatase	Remarks
July 16, 1930	14.3	2.3		
July 25, 1930	12.3	3.2		
September 20, 1932	13.3	2.1	7.5	
September 26, 1932	12.5	2.2		
September 28, 1932	Partial parathyroidectomy			
September 29, 1932	9.4	3.0	5.5	
September 30, 1932	8.5	2.2	5.0	Latent tetany—Chvostek+
October 3, 1932	6.9	3.2		
October 5, 1932	5.8	4.3		
October 6, 1932	5.3	4.2		Mild tetany—paresthesias
October 7, 1932	5.8	4.2		
October 8, 1932	6.0	4.7		
October 10, 1932	5.4	4.5		Moderate tetany—spasm
October 11, 1932		5.5		Relief with calcium chloride
December 20, 1932	8.0	4.0	4.3	Latent hypoparathyroidism
February 7, 1933	7.6	4.3	4.3	Tetany occurred during
August 14, 1933	8.0	3.2		upper respiratory infection
January 4, 1934	9.5	3.6		
January 6, 1934		Pyelolithotomy		
January 18, 1934		Draining kidney		Onset of mild tetany
January 22, 1934	7.0	5.1		
March 12, 1934		Continued kidney sepsis		Mild tetany
October 27, 1934	7.3	5.0	8.4	Recurrent tetany
October 28, 1934	8.1	6.2		No tetany

During the 14 months following operation the hypoparathyroidism remained latent, controlled without signs of tetany by a high calcium intake. In the later months adding a quart of milk a day to the diet proved adequate. Following an elective operation for the removal of renal stones in January, 1934, renal sepsis developed and signs of tetany immediately reappeared. The kidney infection increased in severity and the tetany could be only partially controlled. The phosphorus now rose to higher levels and although the signs of tetany disappeared, the patient died ultimately of renal sepsis and insufficiency. At autopsy January 16, 1935, both kidneys were found destroyed by multiple large abscesses. No parathyroid tissue could be identified. A wide painstaking search failed to reveal a fourth gland. The region of the residual portion of the adenoma, marked at the time of operation by a ring of fine silver wire placed around the pedicle, was occupied by a small abscess and no recognizable parathyroid tissue. The bones of this patient had continued to recalcify until they were abnormally thick and

dense, which had been appreciated by roentgenography more than four months before death. This patient suffered from chronic hypoparathyroidism and tetany due to an insufficient amount of parathyroid tissue. The constant and prolonged need of calcium, the recrudescence of tetany with infection and the autopsy findings led to a diagnosis of hypoparathyroidism persisting from operation to death—a period of two years and three months. Tetany due to skeletal disease alone even in the most severe cases has never approached this duration.

Tetany of the Recalcification Period.—Experiences illustrated by the following case pointed the way to partial resection of an adenoma even at a primary operation when the bone disease is very active.

Case 9.—A man, aged 33, suffered for two years with bone pains and increasing generalized weakness. For three years he noted some degree of polyuria and polydipsia. The very high blood calcium of 16.8 mg., the diffuse calcification of both kidneys revealed by the roentgenograms and the relatively short duration of intense skeletal symptoms pointed toward active bone disease. This was confirmed by the very important finding of a high serum phosphatase of 26 units. A large adenoma was palpable and it was removed in its entirety by a direct operative approach with no attempt to expose the other parathyroid glands.

The operation was promptly followed by very severe tetany that was controlled with difficulty. There was a disturbing degree of mental anxiety and one alarming attack of laryngeal spasm. The signs and symptoms of tetany subsided after three months and completely disappeared within four months. There has been no recrudescence subsequently and as far as can be determined his parathyroid function is normal.

Roentgenologic evidence alone, even though it demonstrates extreme decalcification of the skeleton, does not indicate this dangerous degree of bone activity. In two instances patients have shown roentgenologic evidence of extensive disease of the skeleton but following total removal of an adenoma have exhibited no tetany. These patients have given a long history of skeletal pains associated with generalized decalcification. In both instances the serum phosphatase level was normal, indicating minimal osteoblastic activity. These bones were "empty" but not "hungry."

Case 2.—Miss M. L., aged 55, was one of these two patients. For more than five years she had had aches and pains variously interpreted by her medical advisers as arthritis, flat feet or neurasthenia. During the two years prior to operation she had been practically bedridden. Roentgenograms of the entire skeleton showed generalized decalcification. The cortex of the bones was almost paper-thin. Trabeculae were conspicuous by their absence. The serum calcium was just above normal and the phosphorus was definitely low. The serum phosphatase was 3.2 units, a normal reading. The whole of her small adenoma was removed at operation. The serum calcium dropped to normal, the serum phosphorus level first descended slightly and then returned promptly to normal. There were neither signs nor symptoms of tetany. During the following year her skeleton slowly recalcified with rapid disappearance of her symptoms. Her case has been an outstanding clinical cure of the disease.

Two Stage Operation.—The following case illustrates the conservative handling of a patient with extensive bone disease and a high phosphatase level. It serves as an example of the proper use of partial resection of an adenoma even though a later operation was required for removal of the unexcised portion.

Case 11.—A woman, aged 53, had had skeletal symptoms for 15 years. Three years before admission she had fractured her left forearm and left tibia. Four years before entry at another hospital, a giant cell tumor was removed from her jaw. A fracture of the femur was the precipitating cause of her entering a nearby hospital when the correct diagnosis was made. Roentgenograms showed generalized decalcification of the skeleton of an extreme degree with cysts and giant cell tumors. The serum phosphatase was 16 units. At operation a large parathyroid adenoma was found on the left side weighing approximately 5.5 Gm. Five Gm. were removed and the remaining portion, the tissue around the hilum, was left in an easily accessible position anterior and medial to the left upper pole of the thyroid. Mild transient tetany followed. The serum calcium level which preoperatively was 13.0 mg. descended to 7.4 mg. by the fifth postoperative day. For another two weeks it remained in the neighborhood of 7 mg., then slowly rose until five weeks after operation it was 9.8 mg. The serum phosphorus level increased slowly from a preoperative level of 1.4 mg. to 3.0 mg. five weeks after operation. On discharge from the hospital six weeks after operation there was no evidence of calcification or callus formation at the site of fracture in the femur. A suggested interpretation is that the entire decalcified skeleton was absorbing calcium so fast that the site of fracture was unable to obtain a preferential supply of calcium for healing.

Ten weeks after operation she was readmitted for removal of the plaster spica. The serum calcium was then 11.6 mg. and the serum phosphorus 2.8 mg., indicating a persistent hyperparathyroidism. Her serum phosphatase was now but 5.3 units, a finding of great importance. Because the phosphatase level was nearly normal, it was thought safe to remove the remainder of the tumor. This was done under local anesthesia by direct approach. Seven days after operation the serum calcium was 8.5 mg., serum phosphorus 3.2 mg. There was no tetany. She was discharged on the twelfth postoperative day. A year and one-half after her second parathyroid operation she shows residual deformities from the several fractures which limit motion. Recalcification of her skeleton has been slow but her bone pains have disappeared. Except for the deformities she may be considered a clinical cure. The levels of calcium and phosphorus in her serum have remained normal. The phosphatase level is 5.2 units, still slightly above normal. It is probable that recalcification is still occurring. At the time of the first operation it was thought that a severe tetany would ensue in such a frail and debilitated patient, had the entire adenoma been removed. A partial resection with reduction of the hyperparathyroidism appeared to appease the hunger of the bones, so that when the hyperparathyroidism was finally completely corrected, a high calcium intake was sufficient to prevent any tetany.

Preoperative and Postoperative Treatment.—If there is reason for delaying the operation after the diagnosis has been established, as may occur if the exigencies of a renal complication are present, the diet is to be kept low in calcium. Although a diet rich in calcium and phosphorus might conceivably reduce the danger of postoperative tetany, the hazard of further kidney damage is too great to warrant such a program. Maintenance of an acid urine may minimize the precipitation of calcium phosphate but on the other hand tends to increase calcium excretion. It is probably best to maintain the urinary reaction just on the acid side.

Immediately after the operation the patient is given glucose solution intravenously to stimulate an adequate renal output. A diet high in calcium and low in phosphorus is immediately started, and if the signs and symptoms of tetany appear, additional calcium is given by oral and intravenous routes. If a high calcium diet had been started immediately following the operation

TABLE VIII

Case No.	Clinical Type	Preoperative Studies: Blood Levels Ca.	Phos.	Ptase.	Calcium Excretion	Bone Biopsy	Operations: Date	Procedure	Postoperative Tetany	Follow Up Status: Date	Symptoms	Kidneys	Skeleton	Blood Level Ca.	Phos.	Ptase.	Remarks
1	Classic	13.7	1.9		+	+	12-10-30	Total resection single adenoma	Slight transient	5-15-35	Relieved		Cysts same Calcif.+	8.2	2.6	4.3	Clinical cure
2	Osteoporosis	10.4 12.3	3.6 3.6	3.2	+		1-14-32	Total resection single adenoma	0	5-27-33	Relieved		Calcif.+	10.8	4.3		Clinical cure
3	Nephrocalcinosis	12.1	4.7	36.0	+ in feces	+	4- 9-32	Total resection single adenoma	Moderate prolonged cataracts	5-14-33	Improved	Unimproved	Calcif.+	8.0	6.0		Died 10-5-33, renal insufficiency
4	Classic. Renal stones	14.2	2.3	7.5	+	+	9-28-32	Partial resection single adenoma	Prolonged latent tetany	12-27-34	Relieved	Unimproved	Calcif.+	8.1	6.2		Died 1-16-35, renal infection
5	Renal stones. Osteoporosis	13.0	2.7	4.0	+		10- 3-32	Total resection single adenoma	Slight, transient	10- 8-32				9.3	2.5		Clinical cure but refuses follow up studies
6	Classic. Nephrocalcinosis. Renal stones	13.1 16.5	1.4 3.2	14.2	+	+	11- 2-32	Partial resection single adenoma	Severe								Died 12-14-32, renal insufficiency
7	Classic	13.5	2.4	17.2	+	+	11-15-32	Partial resection single adenoma	Moderate, transient	5-15-35	Relieved		Calcif.+	8.2	3.3	4.9	Clinical cure
8	Classic. ? Paget's. Renal stones	14.0	1.5	18.0	+		11-30-32	Total resection single adenoma	Slight, transient	10-23-34	Relieved	Improved	Calcif.+	10.6	3.8	6.0	Clinical cure
9	Osteoporosis. Nephrocalcinosis	16.8	2.9	26.0	+	+	4- 4-33	Total resection single adenoma	Severe	8- 3-35	Relieved	Unimproved	Calcif.+	10.4	2.1		Hypertension, renal calcification
10	Renal stones	14.0	2.6	4.0	+	? Normal	5-24-33	Total resection single adenoma	None	5-14-35	Relieved	Improved		8.5	3.4	7.5	Cystotomy sinus still draining
11	Classic	13.9	1.6	16.0	+		6-24-33	Partial resection single adenoma	Slight, transient		Improved						
		11.6	2.8	5.3			11-15-33	Resect. residuum single adenoma	0	5-15-35	Relieved		Calcif.+	8.8	2.4	5.2	Clinical cure
12	Renal stones	11.5	3.1	2.7			10- 7-33	Total resection single adenoma	Slight, transient	4-15-35	Relieved	Improved	Normal	9.7	3.5	2.9	Nephrostomy in solitary kidney healed, clinical cure
13	Renal stones	15.8	2.8	4.0		Normal	10-28-33	Total resection single adenoma	Slight, transient	5-18-35	Relieved	Normal	Normal	10.1	3.3	2.8	Clinical cure
14	Renal stones. Osteoporosis	14.5	1.9	6.5			11-29-33	Total resection single adenoma	0								Died 4-23-35, coronary occlusion

15	Renal stones	15.0	2.2	7.3			12–19–33	Total excision two hyperplastic glands	o								1–21–35, cholecystostomy
		14.0	2.3	5.7	+		2–28–34	Subtotal resection third hyperplastic gland	o	7–19–35	Unimproved	Unimproved		11.8	2.6	6.0	
16	Renal stones	16.7	1.7				2–16–34	Total excision two hyperplastic glands	o	7–14–35	Relieved	Improved	Normal	11.9	2.3	4.1	Clinical cure
17	Renal stones	12.4	2.1	4.2			2–14–34	Hyperplasia, total resection three, subtotal fourth	o	6–25–35	Relieved	Improved	Normal	10.8	2.9	3.4	Latent syphilis, clinical cure
18	Osteoporosis	11.6	2.7	5.8		Osteoporosis	4–13–34	Total resection single adenoma	Slight, transient	5–16–35	Improved	Same	Calcif.+	9.9	2.1	7.6	Clinical cure
19	Classic. ? Nephrocalcinosis	15.3	2.4	14.1		+	4–24–34	Partial resection single adenoma	Severe	1–11–35	Rare, tetany	Relieved	No change	9.5	2.9	5.1	Clinical cure, returned to work
20	Renal stones. Osteoporosis	12.4	3.4	7.0		+	6–13–34	Total resection two adenomata	Slight, transient	5–29–35	Relieved	Recurrent hematuria	Recalcification, no visible dis.	9.8	3.7	3.3	Clinical cure
21	Renal stones	11.9	2.9	?		+	6–16–34	2 adenomata, total resection one, partial second	Slight, transient	1–19–35	Improved	Urine loaded with W. B. C.		10.3	3.1		
22	Renal stones	12.0	2.7	2.7		+	7– 6–34	Total resection single adenoma	Slight	10–5–35	Relieved	Relieved		9.0	2.6		Clinical cure
23	Renal stones. Osteochondroma	12.9	2.8	5.7		+	7–12–34	Hyperplasia total resection three, biopsy fourth	Slight, transient	4–12–35	Relieved		Still slight osteoporosis	9.9	3.2	5.3	Clinical cure
24	Renal stones. Paget's	13.0	2.5	20.0	+	Paget's+	10–26–34	Total resection single adenoma	Slight, transient								Has refused follow up
25	Renal stones	13.9	3.0	3.7		Normal	10–27–34	Hyperplasia, total resection three, subtotal fourth	Slight, transient	6– 5–35	Relieved	Relieved		9.7	3.2		Clinical cure
26	Renal stones. Osteopososis	16.4	2.6	4.8		+	2– 9–35	Hyperplasia, total resection three, subtotal fourth	o	10– 8–35	Relieved	Relieved	No change	9.8	3.5	4.3	Clinical cure
27	Classic. Nephrocalcinosis	16.8	2.4	14.1		o	4–12–35	Partial resection single adenoma	Severe, tetany	10–22–35	Relieved		No change	9.0	3.8	9.4	? Clinical cure
28	Classic	13.5	1.5	36.5	+	+	6–13–35	Partial resection single adenoma	? Slight, transient	8– 9–35	Relieved		No change	8.5	2.4	14.8	? Clinical cure
29	Renal stones. ? Nephrocalcinosis	11.5	2.4	2.1		+	7–16–35	Total resection single adenoma	Slight	12–21–35	Improved			9.7	2.4	1.4	
30	Classic. Nephrocalcinosis	18.7	2.9	10.4			1–14–36	Total resection single adenoma	Slight transient	5–28–36	Improved		No change	9.60	5.00	9.8	? Clinical Cure

in our cases it is possible that the occurrence of mild transient tetany would have been avoided entirely. For reasons of academic interest it has been our practice to withhold calcium therapy until definite signs of tetany appeared. From the point of view of rational therapy, however, the patient should be started on the high calcium intake without delay.

If only a positive Chvostek sign appears, no treatment other than high calcium diet is needed. If, however, the Trousseau sign becomes positive and there are definite paresthesias of hands and face, it is wise to prepare for spasms and possible stridor. Large doses of calcium lactate are given by mouth; calcium gluconate and calcium chloride are kept available for immediate intravenous use.

Parathyroid extract is of but limited use in the treatment of postoperative tetany. The injections are often very painful and, more important, a so called immunity develops to limit its use over any long period of time. From a theoretical point of view, except in tetania parathyropriva, supply of calcium is what is needed. Parathyroid extract merely postpones the recalcification of the skeleton. Adjustment of the dosage to allow slow recalcification would be so difficult that we do not recommend its clinical use.

In the tetany of the recalcification period we have but little experience in the use of vitamin D. Theoretically, vitamin D might increase the deposition of calcium, increasing the drop in blood level. If the tetany becomes chronic and is of true hypoparathyroid origin, large doses of vitamin D together with liberal amounts of calcium offer the best method of treatment.

SUMMARY

(1) A rational basis for parathyroid surgery is defined.

(2) The complications of renal stone are discussed.

(3) The normal parathyroid gland is described with particular reference to gross anatomy.

(4) The pathology of the parathyroid bodies is briefly reviewed, recognizing two major types.

(5) The technical steps of the operation are outlined.

(6) The special surgery of generalized hyperplasia is discussed and illustrated by a description of six cases having this type of pathology, three of which are reported in detail.

(7) In five instances parathyroid tumors have been found that were overlooked at previous operations. The technic of these secondary operations is described.

(8) The amount of tissue to be resected when pathologic glands are exposed varies with the type of pathology and the nature of the disease in the individual patient. The criteria for radical or conservative measures are indicated.

(9) Postoperative tetany of two distinct types is described and illustrated by case citations. The treatment of tetany is referred to briefly.

(10) A table is appended summarizing the end-results in 30 cases of hyperparathyroidism treated by operation.

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METASTASES TO THE THYROID GLAND FROM CANCER OF THE COLON

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METASTASES from neoplastic growths usually follow definitely well recognized channels, and appear in certain other viscera with a distinct regularity, depending upon the type and location of the original growth.

Recurrence of colonic and rectal cancer in the thyroid gland is of such extremely small incidence that it is an unique observation. For this reason we wish to report in some detail a case which was followed over a period of four years and the autopsy findings of which revealed, in addition to the customary metastases, one in the thyroid gland.

CASE REPORT

W. N. O., male, aged 54 years, was examined April 28, 1931, having been referred with a diagnosis of carcinoma of the ascending colon with mild obstruction, and in addition, a benign polyp of the sigmoid.

Present Complaint.—Pain in abdomen which came on acutely April 23, 1931.

Present Illness.—Patient states that on April 23, 1931, during the night he began to have some pain in the epigastrium which was griping in character. It came on in paroxysms and seemed to be relieved by the passage of flatus. It was not severe, although it did double him up at times. A small enema gave him some relief. Since this time he has had a few twinges of pain but has not been distended as he was during the acute attack. He has had no previous gastro-intestinal distress of any kind.

About one year ago he noticed blood in the stool, and on proctoscopic examination a small polyp from which blood was oozing was discovered in the rectum. There were several recurrences of this bleeding, the last being in March, 1931, at which time gastro-intestinal series was postponed to allow the bleeding to stop. His appetite has always been good, he has had no colics, jaundice, loss of weight, or vomiting, and has had good bowel movements, having regularly a morning stool, and has no history of any bowel infections or any attacks of alternating diarrhea and constipation.

Previous Health.—General health has been excellent and the history by systems is negative.

Family History.—Father and one elder brother died with coronary attacks, otherwise history is essentially negative.

Marital History.—Wife living and well; four children living and well; one child has congenital bilateral dislocation of the hips.

Physical Examination.—Patient is a well developed and well nourished white male, aged 54 years, a physician, apparently not acutely ill at present. No appearance of jaundice. Blood examination showed white cells, 8,600; red cells, 4,150,000; hemoglobin, 87 per cent. Urinalysis—normal.

Roentgenogram of the chest—negative except for some calcification in the region of the left hilus. No evidence of a metastatic lesion.

Proctoscopic Examination.—Normal rectal lining for 24 cm.

Roentgenologic Examination of Colon.—An annular carcinoma just proximal to the hepatic flexure.

A diagnosis of cancer of the colon having been made, the patient was put on a

preoperative decompressive and rehabilitory regimen, and on May 4, 1931, was operated upon. The operative note is as follows: "There is a cancer of the right colon below the hepatic flexure. No metastases could be discovered. An aseptic ileocolostomy was made over the Rankin clamp between the terminal ileum and the middle of the transverse colon. The cecum was found bound down in the site of an old appendectomy scar. A great deal of fat was in the mesentery of the transverse colon and the operation was technically difficult. Spinal anesthesia had to be supplemented with gas-ether."

Following this preliminary by-passing of the fecal current, the patient was returned to his home to await a subsequent resection which was undertaken on July 13, 1931. The following is the operative note: "Right rectus incision. Resection of the right colon and one-half of the transverse colon, going at least ten inches beyond the hepatic flexure. The resection was accomplished easily and satisfactorily. The end of the colon was turned in and brought out under the skin. The blood supply was satisfactory on inspection. Peritonealization was easily accomplished. A Penrose drain and one split tube were left in the intraperitoneal space for drainage."

Pathologic Report.—"Specimen shows 17 cm. of ileum and in addition, the cecum and ascending colon. Diagnosis.—Annular, Grade II, adenocarcinoma (Fig. 1), 3 cm. long with its proximal margin 9 cm. from the ileocecal junction. There is one node involved."

Postoperative Course.—The patient had a relatively easy convalescence and was dismissed from the hospital during the third postoperative week. He returned home and regained his strength quickly and became actively engaged in his profession. On July 11, 1932, he returned for a re-check, at which time a roentgenologic study of his chest was negative except for the calcification at the left hilus which had been noted at the previous examination; that of the colon showed the anastomosis to be functioning well and no evidence of recurrence in the bowel. There was a diverticulitis of the sigmoid with moderate spasm, which had been noted at his first examination.

The patient continued in robust health, and practised his profession actively until the late summer of 1934 when he began to become fatigued more easily than normal but without any very definite symptoms of a return of malignancy. A roentgenologic study of the stomach and bowel on July 28, 1934, was negative, as was that of his chest.

He continued to work until the middle of December, 1934, when it became evident that he was losing ground. A check-up at this time was undertaken because of a paralysis of his right vocal cord, which developed suddenly. A roentgenogram of his chest at this time did not show definite metastases and no lumps were palpable in the abdomen, nor was the liver apparently enlarged, but the thyroid gland was definitely enlarged and some small lymphatic nodes, which were hard, could be felt in the triangles of the right side of the neck.

In January of 1935 he began to decline rapidly and was confined to his home. On March 3, 1935, he died.

Autopsy.—The body is that of a man appearing older than the stated age of 58. External examination shows moderate emaciation. There is a swelling on the right side of the neck along the course of the anterior chain of cervical lymph nodes extending across to the region of the thyroid gland and giving rise to a mass 6 by 6 by 3 cm. lying above the right clavicle. There is slight enlargement in the region of the left lobe of the thyroid. The surgical scars on the right side of the abdomen are in no way remarkable.

On opening the abdomen, no free fluid is found, but the omentum is tightly bound by old adhesions to the abdominal wall and to coils of small intestine in the right iliac fossa. The cecum, ascending colon, and hepatic flexure are absent, the transverse colon being closed blindly and anastomosed to a loop of ileum. The anastomosis is widely patent and there is no evidence of neoplasm in the bowel or tissues adjacent to the

operative site. The remainder of the colon, the small intestine, and the stomach are normal.

The liver is markedly enlarged, extending 5 cm. below the right costal margin and projecting well over into the left upper abdominal quadrant. Section shows the right lobe to be practically entirely replaced by a neoplastic mass, while there are smaller metastases throughout the left lobe. The gallbladder is not involved by neoplasm, but the common bile duct is surrounded by a mass of tumor which has caused a partial obstruction. The pancreas, while lying in close proximity to a mass of cancerous nodes, is not involved by metastases.

FIG. 1.—Photomicrograph from section of operative material removed in 1931. The diagnosis is Grade II adenocarcinoma. The microscopic appearance is very similar to that seen in sections from the liver and lungs removed at autopsy four years later.

Anterior to the vertebral column is a continuous chain of neoplastic lymph nodes, extending to and involving the bronchial nodes. Both kidneys show marked metastatic involvement, that on the right being much more extensive. A tumor mass replaces the medulla of each adrenal, being surrounded by a thin yellow ring of cortical tissue. The cancer nodule in the right adrenal measures 6 by 4 by 4 cm. and that in the left 2 by 1.5 by 1 cm. The spleen, while enlarged, shows no evidence of neoplasm. The urinary bladder and genital organs are not unusual.

Within the chest no excess of fluid is found in any serous cavity. In the lower lobe

of the right lung is a large mass of neoplasm over which is recent fibrinous pleuritis binding visceral to parietal pleura. Scattered throughout both lungs are metastases varying in size up to 3 cm. in diameter. The lower left lobe is red and firm, typical of consolidation. The heart is smaller than normal and the musculature has a chocolate color. The right side is dilated. There is moderate sclerosis of the coronary vessels and the mitral valve cusps are thickened. Moderate atheromatous change is present in the aorta.

The neck organs, trachea and mediastinal structures were removed *en masse*. The cervical nodes on the right are completely replaced by neoplastic tissue. In the right lobe of the thyroid is a tumor mass measuring 4 by 2 by 2 cm. and in the left lobe a similar mass measuring 3 by 1.5 by 1 cm. No normal thyroid is discernible on gross inspection. There is a cancerous area in the mucosa of the larynx on the right side just below the vocal cord.

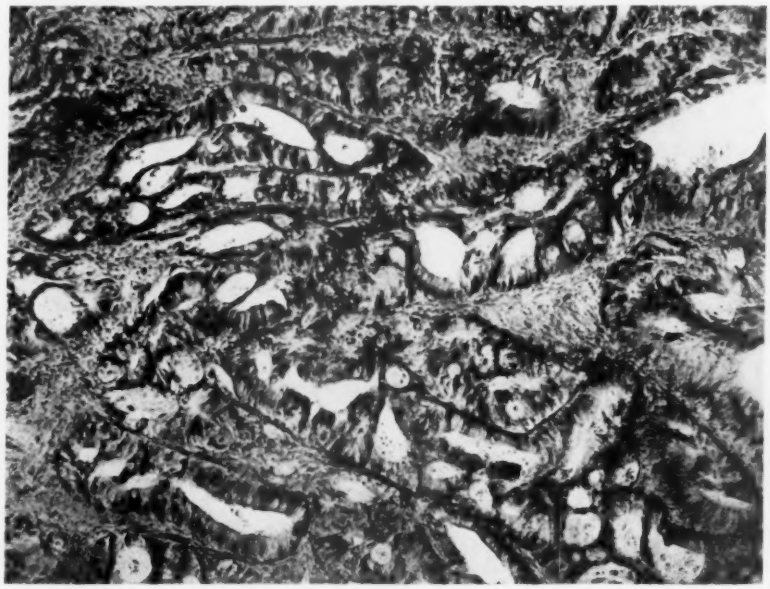

FIG. 2.—Dissection of thyroid and larynx. The thyroid has been sectioned, showing the large white mass of neoplasm replacing the right lobe. The left lobe has more the appearance of normal thyroid and does not reveal in the photograph the large amount of neoplastic infiltration which is present.

Tissues from all organs—except the brain, which was not removed—were examined microscopically, but only those showing neoplasm are reported here (Fig. 2). In the lungs, which also show areas of acute edema and foci of acute purulent lobular pneumonia, the metastases show definite adenomatous architecture similar to that seen in the operative material. The carcinoma cells are in many areas mucin producing. The smallest metastases are in the lumina of blood vessels. The neoplasm in the liver is quite similar to that in the lungs. In the kidneys the differentiation is less marked and there is some necrosis. Both adrenal medullae are completely replaced by metastatic carcinoma, but the thin layer of cortex surrounding the tumor is normal in appearance except for small inflammatory foci. The most undifferentiated areas are in the lymph nodes and in the thyroid, where the adenomatous architecture, although still present, is less well preserved and the cells show many mitotic figures. There are large areas of caseation necrosis in the neoplasm. The right lobe of the thyroid is entirely replaced by carcinoma, only a few small islands of recognizable thyroid tissue being present. The left lobe is infiltrated throughout by neoplasm, but there is considerable remaining thyroid tissue.

Pathologic Diagnosis.—Generalized adenocarcinoma (primary lesion in previously removed ascending colon). Multiple metastases in prevertebral lymph nodes, liver, larynx, both adrenals, lungs and both lateral lobes of the thyroid. Terminal purulent lobular pneumonia. Early atheromatous changes in aorta and coronary vessels. Brown atrophy of heart. Serous atrophy of fat tissue. Cloudy swelling of all parenchymatous tissues.

The point which distinguishes this case from an ordinary generalized carcinomatosis is the occurrence of metastases in the thyroid. As has been repeatedly noted, cancer of the large bowel is less apt to produce distant metastases than neoplasm arising elsewhere in the gastro-intestinal tract. Further, carcinoma in the upper portion of the colon is less prone to distant spread than that occurring in the rectum. The mucin formation in this tumor is deserving of further comment. As pointed out by Rankin and Chumley, mucin production in colonic tumors is of two types. In the first group there are many goblet cells and the mucoid change represents a differentiation of the carcinoma toward the normal function of colonic mucosa. These tumors are not prone to distant metastases and are among the less highly malignant of intestinal cancers. The other group is highly undifferentiated and the mucin is present within highly atypical cells—the so called signet-ring cells. These tumors are highly malignant and are prone to metastasize early and widely. The mucin formation in this particular carcinoma is of the first mentioned type. The spread of this neoplasm has been by both hematogenous and lymphatic routes. The involvement of the thyroid is undoubtedly by way of the adjacent carcinomatous cervical lymph nodes. In spite of the proximity, however, such an occurrence is extremely rare. In carcinoma of the colon it is even less frequent and in the particular type of cancer represented by this case, it is most unusual.

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THE FALL IN BLOOD PRESSURE DURING SPINAL ANESTHESIA

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FATALITIES have been numerous after the subarachnoid injection of anesthetic drugs. Fortunately, these are becoming less and less frequent. However, such accidents are still common enough to warrant further investigation into the mechanism which produces such a rapid and marked fall in blood pressure, and leads to a state simulating shock and occasionally to death of the patient. Many theories have been proposed and many experiments performed in an effort to determine the cause of this fall in blood pressure. Important facts have been brought to light, but none of them seems quite adequate.

A brief résumé of the prevalent ideas concerning the cause of the fall in blood pressure reveals the confusion that exists. The following have been given as causative factors:

(1) Muscular relaxation and diminished negative intrathoracic pressure due to abdominal and lower thoracic paralysis—Gray and Parsons.[1]

(2) Splanchnic dilatation—Smith and Porter.[2]

(3) Cerebral anemia due to splanchnic dilatation—Labat.[3]

(4) Diffusion of the anesthetic into the medullary region—CoTui and Standard.[4]

(5) Vascular absorption of the anesthetic and its subsequent systemic effects—Nowak.[5]

(6) Vasomotor paralysis and sudden absorption into the blood stream of novocaine—Jones.[6] Jones states that sudden absorption is by far the greater factor. No experimental proof is offered to substantiate the vasomotor paralysis theory.

Since vasomotor paralysis has been mentioned so frequently as a causative factor, it was decided to sympathectomize animals completely, thus eliminating the vasomotor control, and see what effects, if any, the subarachnoid injection of procaine would have on the blood pressure of these animals .

Procedure.—Five healthy cats were anesthetized by the intraperitoneal injection of sodium barbital (.45 Gm. per kilogram). A carotid cannula was inserted for recording blood pressure. The animals were then subjected to a laminectomy at the second or third lumbar level. Metz procaine crystals were dissolved in normal saline to make a 10 per cent solution. To each cubic centimeter of this solution was added one drop of aniline gentian violet. Each animal was given 10 mg. of procaine for each kilogram of body weight. This dosage is four or five times the amount usually given to patients. The gentian violet allowed the determination of cord level reached by the colored solution and the detection of any leakage about the needle puncture in the

dura. The dural puncture was made under direct vision always at the second or third lumbar level. By means of a time marker on the kymograph record the rate of injection could be kept fairly constant.

Figure 1 is a typical record. All the control animals showed a lowering of blood pressure, of the same order of magnitude as did Nowak's[5] control animals. Table I shows the uniformity of these results.

TABLE I

SPINAL ANESTHESIA IN NORMAL ANIMALS

Experiment No.	Wt. in kilos.	Height of colored fluid	Blood pressure Before	Blood pressure Lowest after
2	3.25	7C.	90	60
5	3.50	4T.	135	60
15	3.15	5T.	95	60
16	3.17	5T.	120	60
17	3.52	4T.	130	90

Four cats were completely sympathectomized in stages, the thoracic chain on one side and both abdominal chains being removed at the first operation. A recovery period of ten days to two weeks was allowed and the remaining thoracic chain was taken out. A second recovery period of ten days was allowed before making the subdural procaine injection. Occasionally the entire sympthetic chain of one side was removed intact, including the stellate in the neck and ganglion impar at the coccyx.

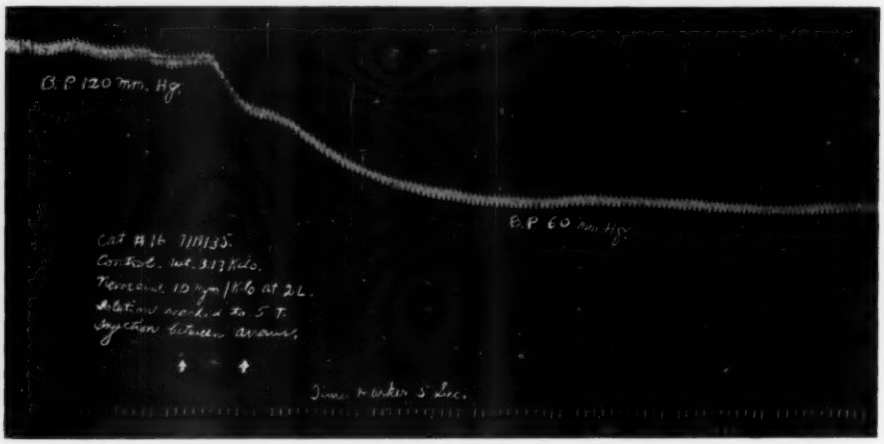

FIG. 1.—Normal cat. Weight, 3.17 kilo. Subarachnoid injection of 10 mg. novocaine per kilo at second lumbar level. Colored solution extended to fifth thoracic level.

These animals were then subjected to exactly the same procedure as the control animals. Fig. 2 is a kymographic record of one of these experiments. The other records are all similar. It clearly shows the difference in blood pressure response to subdural procaine injection in this and the control animal. Table II shows a similar response in all the sympathectomized animals.

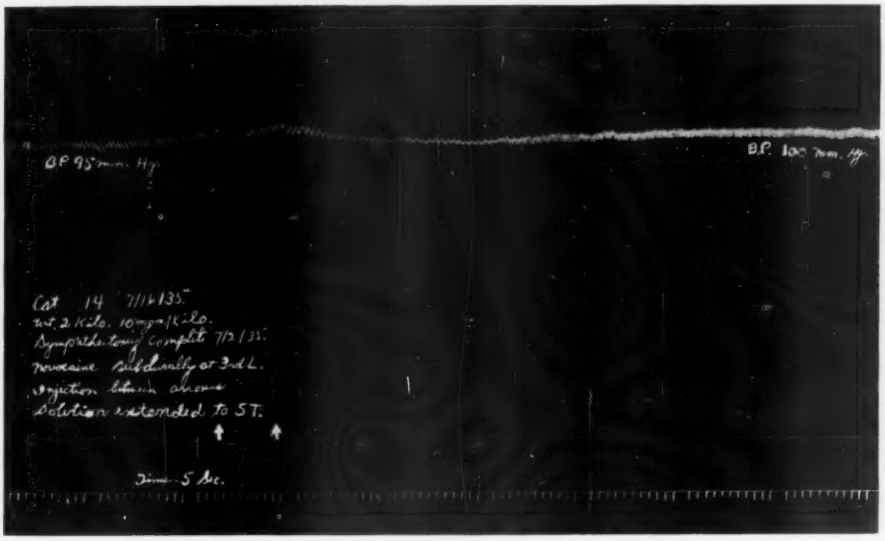

FIG. 2.—Sympathectomized cat. Weight, 2.0 kilo. Subarachnoid injection of 10 mg. novocaine per kilo at third lumbar level. Colored solution extended to fifth thoracic level.

TABLE II

SPINAL ANESTHESIA IN SYMPATHECTOMIZED ANIMALS

Experiment No.	Wt. in kilos.	Height of colored fluid	Blood pressure	
			Before	Lowest after
4	3.70	7C.	80	75
7	2.21	4T.	95	90
12	2.30	5T.	80	85
14	2.00	5T.	95	100

Comment.—These experiments demonstrate the rôle of the vasomotor system in the fall in blood pressure that occurs during spinal anesthesia. This fact has long been recognized by some surgeons on more or less empirical grounds. So far as we are aware, it has never been clearly demonstrated in a series of experimental animals.

Although it is true that in the sympathectomized animals the blood pressures are lower before the subdural injection is made, cats number 2 and 15 in the control group also had a low blood pressure before the procaine was injected. They both had definite falls in pressure, however, after the injection.

From these studies there is no indication that the height of the anesthesia, within limits, is of great importance in causing the fall in blood pressure. In the control series there was no greater fall when the colored solution reached the seventh cervical level than when it had reached only the fifth thoracic level. It would appear, therefore, that the vasoconstrictor fibers from the fifth thoracic level down are the important fibers in the most common type of blood pressure reaction occurring under spinal anesthesia.

When high concentrations of the anesthetic drug reach the cervical cord and higher regions, respiratory failure occurs. Schief and Zieg-

ner[7] tied ligatures around the dura in the upper thoracic cord and made injections above these ligatures. This led to respiratory failure. Thompson[8] made injections into the ventricles and the cisterna magna which produced respiratory failure followed immediately by a fall in blood pressure. When lumbar injections were made there resulted an immediate fall in blood pressure, an apparent paralysis of intercostal muscles, and a gradual failure of diaphragmatic respiration. If the lumbar injection was preceded by ephedrine this series of events did not occur. Ferguson and North[9] observed respiratory collapse when the injection was made above a ligature at the eighth cervical level. They also demonstrated marked falls in blood pressure with variable effects on respiration when the injection was limited to the region between the eighth cervical and the fifth or sixth thoracic segments. These authors state that the entire vasomotor system participates in a vasodilation and the degree of blood pressure depression is in direct ratio to the number of white rami anesthetized.

It seems reasonable to assume that in some instances sufficient concentration of a drug used for spinal anesthesia may be present in the higher cord region and produce complete intercostal paralysis, phrenic paralysis, and paralysis of medullary centers, in addition to complete sympathetic nerve paralysis. However, such a condition must be rare. It seems extremely unlikely that such a concentration can exist if the drug had been injected in proper dosage and with proper technic, in the lumbar subarachnoid space. It is also assumed that occasionally during the subarachnoid injection of a drug a vein may be entered with the sequence of events described by Hatcher and Eggleston[10] as following the rapid injection of procaine into a vein.

From a practical point of view it would seem that certain measures are indicated by these experiments to prevent his fall in blood pressure.

(1) The preliminary administration of some vasoconstrictor drug which produces constriction by direct action on the arterioles. Probably ephedrine is the best drug available at present.

(2) The use of small doses of drugs employed for spinal anesthesia.

(3) The limitation of drugs injected subdurally to small segments of the spinal cord so that as few vasoconstrictor fibers as possible are paralyzed.

CONCLUSION

The fall in blood pressure following the injection of procaine for spinal anesthesia is due to a paralysis of vasoconstrictor nerve fibers.

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EVIPAL ANESTHESIA IN THORACIC SURGERY*

STUDIES IN ONE HUNDRED THORACOPLASTIES FOR PULMONARY TUBERCULOSIS

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THE reason we were induced to try Evipal in our thoracoplasties for pulmonary tuberculosis is that we do not as yet possess the suitable anesthesia for these cases. In our work at Sea View and Metropolitan Hospitals of the City of New York, in which an average of 400 thoracoplasties have been performed yearly during the past four years, we have successively used spinal, local and general anesthesia, alone or combined, without complete satisfaction. Spinal anesthesia was discarded because of the frequently marked drop of blood pressure caused by it, which could not always be controlled; local anesthesia, because it seldom insured the painless operation which is necessary in patients who have to be submitted to several stages. General anesthesia with gas-oxygen-ether was the simplest and most satisfactory, except for the fact that it predisposes to the development of respiratory complications during and after operation. As has been previously demonstrated,[7, 8] these patients are in a state of chronic anoxemia and are therefore particularly vulnerable to even slight disturbances of respiration. Accumulation in the trachea of bronchial exudate during thoracoplasty is sufficient to cause acute anoxemia and to start the vicious cycle of rapid shallow breathing, acapnia, periodic breathing, drop of blood pressure and rapidly increasing oxygen unsaturation of hemoglobin, which leads to fatigue of the respiratory center and apnea. Still more dangerous are postoperative pulmonary inflammatory complications which are responsible for nine-tenths of our postoperative morbidity and mortality.[9] Although we do not accept the so called postoperative ether pneumonia,[7] we are obliged to recognize that any marked limitation of the respiratory field, already restricted by the tuberculous lesions of the lung and the collapse of part of this organ produced by the operation, may suffice to start the above-mentioned cycle. Prolonged postoperative sleep and suppression of the cough reflex favor bronchiolar obstructions, which are the principal factors in the production of postoperative lobular or lobar atelectasis, bronchopneumonia and pneumonia (Coryllos and Birnbaum[11]). Therefore, the ideal method of anesthesia in these cases appears to be one which would insure the patency of the respiratory ways, the removal of exudate expressed from the lung collapsed by the operation, the prevention of its draining into the bronchi of the healthy lung and the rapid reestablishment after operation of the natural means of defense of the lung and more especially of the cough reflex.

We have partly satisfied these requisites by the use of an intratracheal

* Received for publication, July 29, 1935.

catheter which insures patency of the respiratory ways and allows removal of the bronchial exudate by suction during operation.[7, 8] Furthermore, by packing the oropharynx around the catheter we have obtained separation of this cavity from the larynx and thus have been able to prevent passage of infected secretions from the upper into the lower respiratory tract. The marked improvement in the results in the last 600 thoracoplastic operations has shown the efficiency of this procedure.[9, 10]

In order to decrease the amount of anesthetic administered through the respiratory passages, we have used avertin[10] as a basal anesthetic in some 300 thoracoplastic operations at Sea View and Metropolitan Hospitals. The dose was kept under 80 mg. per kilogram of body weight. This procedure rendered possible the use of more liberal amounts of oxygen during operation and of more frequent bronchial suction. However, it presented two important inconveniences: first, a period of more or less marked agitation and restlessness following operation, which greatly increased the metabolic needs of oxygen of these already anoxemic patients; second, it was often followed by a prolonged sleep during which the patient did not cough or expectorate, which favored stagnation of the exudate in the bronchial tree.

For these reasons we decided to try a new compound of barbituric acid, known as Sodium Evipan in Europe, and recently introduced into this country under the name of Evipal Soluble. The rapid oxidation in the organism and elimination of this product, the shortness of anesthesia produced by it, its relatively large margin of safety and the facility of its administration, recommended it for our work. A previous careful timing of the different stages of our thoracoplastic operations, all performed by the technic previously described,[10] had shown us that the average time for a first stage was from 20 to 45 minutes and for the second and third stages from 15 to 30 minutes; therefore it appeared that if we administered this anesthetic just before the beginning of the operation we could carry on the operation or at least the longest part of it without any additional anesthetic. One hundred thoracoplasties were performed under Evipal anesthesia by this procedure. In every case the anesthesia was given by one of us (S.B.) and conducted as a physiologic experiment. The time of the administration of the anesthetic was registered, blood pressure, pulse and respiration rates were taken every three minutes, the condition of the reflexes, the color of the patient and such phenomena as cyanosis, tremor, *etc.*, were carefully noted. In a number of cases in which gas-oxygen or oxygen-carbon dioxide was added, the blood pressure, respiration and percentages of gases were recorded by means of the anesthesia recording apparatus of McKesson.

We wish to report here the results obtained in these 100 consecutive cases of thoracoplasty for pulmonary tuberculosis, in which the results have been consistently favorable.*

TECHNIC.—In our work we have used the product known as Evipal Soluble.

Preliminary Medication.—In all of our cases we use grain 1/3 of pantopon

* The results of a new series of 300 cases were published recently.[33]

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We have partly satisfied these requisites by the use of an intratracheal

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catheter which insures patency of the respiratory ways and allows removal of the bronchial exudate by suction during operation.[7, 8] Furthermore, by packing the oropharynx around the catheter we have obtained separation of this cavity from the larynx and thus have been able to prevent passage of infected secretions from the upper into the lower respiratory tract. The marked improvement in the results in the last 600 thoracoplastic operations has shown the efficiency of this procedure.[9, 10]

In order to decrease the amount of anesthetic administered through the respiratory passages, we have used avertin[10] as a basal anesthetic in some 300 thoracoplastic operations at Sea View and Metropolitan Hospitals. The dose was kept under 80 mg. per kilogram of body weight. This procedure rendered possible the use of more liberal amounts of oxygen during operation and of more frequent bronchial suction. However, it presented two important inconveniences: first, a period of more or less marked agitation and restlessness following operation, which greatly increased the metabolic needs of oxygen of these already anoxemic patients; second, it was often followed by a prolonged sleep during which the patient did not cough or expectorate, which favored stagnation of the exudate in the bronchial tree.

For these reasons we decided to try a new compound of barbituric acid, known as Sodium Evipan in Europe, and recently introduced into this country under the name of Evipal Soluble. The rapid oxidation in the organism and elimination of this product, the shortness of anesthesia produced by it, its relatively large margin of safety and the facility of its administration, recommended it for our work. A previous careful timing of the different stages of our thoracoplastic operations, all performed by the technic previously described,[10] had shown us that the average time for a first stage was from 20 to 45 minutes and for the second and third stages from 15 to 30 minutes; therefore it appeared that if we administered this anesthetic just before the beginning of the operation we could carry on the operation or at least the longest part of it without any additional anesthetic. One hundred thoracoplasties were performed under Evipal anesthesia by this procedure. In every case the anesthesia was given by one of us (S.B.) and conducted as a physiologic experiment. The time of the administration of the anesthetic was registered, blood pressure, pulse and respiration rates were taken every three minutes, the condition of the reflexes, the color of the patient and such phenomena as cyanosis, tremor, *etc.*, were carefully noted. In a number of cases in which gas-oxygen or oxygen-carbon dioxide was added, the blood pressure, respiration and percentages of gases were recorded by means of the anesthesia recording apparatus of McKesson.

We wish to report here the results obtained in these 100 consecutive cases of thoracoplasty for pulmonary tuberculosis, in which the results have been consistently favorable.*

Technic.—In our work we have used the product known as Evipal Soluble.

Preliminary Medication.—In all of our cases we use grain 1/3 of pantopon

* The results of a new series of 300 cases were published recently.[33]

one-half hour before operation. Ephedrine grain ¾ was given hypodermically just before the administration of the anesthetic, in a few cases. We found that ephedrine checked considerably the tendency of Evipal to produce an immediate and marked drop in blood pressure. No other barbiturates were used before operation.

Injection.—As the duration of anesthesia is very short (10 to 30 minutes) we adopted the technic of placing the patient on the operating table, which is a rather long procedure in thoracoplasties, and of preparing the field and placing the sterile sheets, before the injection of the anesthetic. When the intratracheal catheter was used, as was done on all patients expectorating over 20 cc. of sputum in twenty-four hours, it was introduced beforehand under local anesthesia of the throat and larynx with 2 per cent nupercaine. The solution of Evipal was then slowly injected into a vein in the arm.

Dosage.—In order to determine the amount necessary to produce sleep (hypnotic dose) the patient was asked to count in a loud voice, or in cases in which the intratracheal catheter was used and the patient could not talk, he was instructed to count by moving the fingers.

The determination of the hypnotic dose is of importance because it allows an estimate of the total dose which can be given safely. Menegaux and Sechehaye[23] have analyzed over 23,000 cases of Evipal anesthesia. In this paper they consider relaxation of the masseter muscles and the "drop of the jaw" as the best criterion of the onset of sleep. "The drop of the jaw" according to these authors "is more sudden than in any other kind of anesthesia." The dose necessary to produce this phenomenon can be doubled without danger and should be, in order to obtain the full effect and duration of anesthesia with Evipal. We have not been able to corroborate the relaxation of the masseter muscles. Very often little or none was obtained and in some cases the opposite effect was noticed. Therefore as the criterion of the hypnotic dose we have elected the number of cubic centimeters given until the onset of sleep, indicated by cessation of counting by the patient. This dose can be safely doubled.[33] In this series, however, without disregarding this point, we have routinely injected, with only a few exceptions, 10 cc. of the 10 per cent solution, that is, 1 Gm. of Evipal; and have not employed more than this amount.

The sleep caused by Evipal is comparable to natural sleep. The patient rapidly loses consciousness without any disagreeable sensation. The narcotic effect is evidenced by moderate snoring, often by cough, sometimes by tremor of short duration. Generally 4 cc. suffices to produce sleep and slight analgesia.

The dosage of anesthetic according to the weight of the patient seems to be of importance, especially in emaciated subjects. There can be no doubt that by giving all patients the same dose of Evipal (1 Gm.) we get a more marked anesthesia and a more prolonged narcotic action in lighter rather than in heavier patients. However, the dose of 1 Gm. has proven to be without untoward effects in patients weighing as little as 85 pounds

when injected slowly, provided they were not toxic. It has been shown that in patients weighing less than 100 pounds the duration of complete anesthesia was from 49 to 27 minutes, an average of 31 minutes; in only two instances was additional anesthesia necessary. The time that elapsed from the administration of the anesthetic to the return to consciousness varied in these cases from a minimum of one hour and ten minutes to seven hours and 57 minutes, an average of three hours and 30 minutes. On the contrary, in cases weighing over 150 pounds, the duration of complete anesthesia varied from eight to 27 minutes, an average of 15 minutes, and they were fully conscious from one to three hours and 49 minutes, an average of two hours and 15 minutes. In all of these latter patients except one additional anesthesia was necessary.

Speed of Injection.—It is generally recommended to inject no more than 1 cc. every ten seconds. We have always followed this rule. Monad[25] and Jentzer[19] have insisted on the advantages of slow injection in order to avoid any "blood wave oversaturated with Evipal" from coming in contact with the bulbar centers. Bennhold[2] showed that the proteins of the blood have a limited ability to combine with Evipal, and following a massive and rapid injection, this substance may remain free and damage the centers of the bulb. Rostock[28] and Menegaux and Sechehaye[23] attributed four instances of transient apnea to an excessive speed of injection. Furthermore, accurate determination of the hypnotic dose can be obtained only by slow injection. On the other hand, Anschütz[1] has shown that too slow an injection may cause failure of anesthesia, as the rapidity of the destruction of the substance in the organism may prevent it from reaching the degree of concentration necessary for the induction of anesthesia. In our cases we have found that the best anesthesia was obtained by injecting 1 cc. in ten seconds, an average total time of 100 to 120 seconds for 10 cc.

Course of Anesthesia.—As has already been stated, the induction of anesthesia is smooth and without any objective or subjective symptoms. The patients present the aspect of natural sleep. Occasionally there is a slight cyanosis, or a slight tremor which are transient. It is seldom that generalized tremor has been observed. The only really alarming symptoms are excessive pallor and apnea which may follow very rapid injection or overdosage. We had no such complications in this series.

Reflexes.—The corneal reflex disappeared as the narcotic dose was reached. The reflex to light, on the contrary, persisted in a number of cases. In a few instances the corneal reflex persisted, although a good anesthesia was obtained. In a general way the pupils contracted at the onset of the anesthesia and then gradually dilated. More frequently the condition of the pupils varied to such an extent that it could not serve as a guide for the anesthetist as in inhalation anesthesia.

Opinions are at variance concerning the action of Evipal on the laryngeal reflex. Kriebel[20] reported that it is always abolished whereas in all of Ropke's cases it had persisted. We do not entirely agree with Ropke, as

in two cases of bronchoscopy and esophagoscopy we were obliged to postpone the procedure because of the persistence and even an increase of the reflexes of the pharynx, larynx and bronchi. In all of these cases these procedures were carried out a few days later under local anesthesia with 2 per cent nupercaine without any difficulty.

Pain reflex, especially during incision of the skin, was present in five cases, and was manifested by a more or less marked movement of the patient. However, in all these cases, section of the muscles and periosteum and resection of the ribs were painless.

Action upon Circulation and Respiration.—Of far greater importance are the changes occurring in the blood pressure, and in the rate and quality of pulse and respiration. All of our cases were analyzed and segregated to operative stages, in order to determine the respective effects of the anesthesia and of the operation upon these phenomena. Although the first stage of thoracoplasty is longer in duration and causes more shock than the second and third stages, it should not be forgotten that the patient often comes to the second and third stages in poorer physical condition than he was in the first stage. In the majority of these cases the variations of blood pressure were very marked. In 27 of our 100 cases the blood pressure fell within one to two minutes following the injection of Evipal, and could not be obtained; this condition lasted from two to five minutes. We wish to state, however, that the drop was not accompanied by any symptoms of shock; it had little effect upon the color of the patient or the rate of respiration. The pulse was palpable in all cases, in the temporal artery. Therefore this initial drop of blood pressure should be differentiated from any later drop which is due to postoperative shock.

At the beginning of this investigation, two cases were operated upon under combined local infiltration with novocain and Evipal anesthesia. In both, within three minutes after injection of Evipal, the blood pressure could not be obtained; the same fall of blood pressure occurred in a third case, although the initial systolic pressure was 144 Mm. Following this experience we adopted the procedure of injecting, routinely, one ampoule of ephedrine, gr. ¾, subcutaneously, immediately before the injection of Evipal, and have considerably decreased the instances of marked drops in systolic pressure, without, however, being able to eliminate them completely.

In five cases in which no ephedrine was used, the average drop was 92 Mm., from an average initial systolic pressure of 130 Mm. (*i.e.*, 70 per cent of the initial pressure). In our calculations we have accepted that the systolic pressure is around 40 Mm., when it cannot be registered in the arm, although the pulse can be felt in the temporal artery. In the cases in which ephedrine was used the average drop was 25 Mm. on an average initial pressure of 129 Mm. (*i.e.*, 19 per cent of the initial pressure). In all cases, except one, in which marked operative shock developed, the pressure returned to practically normal levels at the end of the operation. Therefore it seems reasonable to consider that this initial drop of blood pressure was due to

Evipal and not to the operation. Likewise the differences between initial and terminal pressures were not greater following first stage thoracoplasties, than following second or third stage procedures. Thus in 48 first stages the average of the initial systolic pressure was 123 Mm.; the average at the end of the operation was 104 Mm., an average drop of 19 Mm., representing 15 per cent of the initial systolic pressure. In 38 second stages the average initial systolic pressure was 127 Mm., and at the end of the operation 108 Mm., a drop of 16 Mm. (*i.e.*, 13 per cent of the initial pressure). In 12 third stage operations the average initial systolic pressure was 138 Mm. and at the end of the operation 117 Mm., an average drop of 21 Mm. (*i.e.*, 15 per cent of the initial systolic pressure). In other words, the drop was approximately the same in all stages notwithstanding the considerably greater traumatism caused by the first than by the second and third stages. It is reasonable, therefore, to conclude that the drop at the end of the operation was due to the anesthetic.

The fall of blood pressure caused by Evipal is better appreciated when we consider the drop occurring one to three minutes following injection. In our 43 first stages, the average initial pressure was 123 Mm. If we admit that the systolic pressure in cases in which it could not be recorded with the sphygmomanometer was approximately 40 Mm., we find that the average lowest pressure was 74 Mm. mercury, that is an average drop of 50 Mm. (40 per cent). In the 38 second stages with an average initial pressure of 127 Mm. the average lowest pressure was 49 Mm., an average drop of 78 Mm. (61 per cent). In the third stages with an average initial pressure of 138 Mm. the average lowest pressure was 88 Mm., a drop of 50 Mm. (36 per cent). Thus following Evipal injection there was an average drop of 46 per cent within five to 15 minutes.

We wish to stress, however, the point that since we have been using Evipal anesthesia the number of cases of operative shock has been markedly reduced. In the present series of 100 consecutive operations, from August 7 to November 20, 1934, there was only one case with marked postoperative shock; and this was the only operative death occurring among them.

Pulse and Respiration.—In all cases the pulse was markedly accelerated during operation with a tendency to slow down at the end. In three it was slightly lower at the end of the operation and in two it remained unchanged. In one-third of our cases the pulse was more rapid than normal before the anesthesia, due to the apprehension of the patient during preparation. During the operation it varied between 110 and 165, averaging approximately 150, which has obtained in our thoracoplasties, irrespective of the kind of anesthesia employed. It was also noted that the average pulse rates were about the same in cases with Evipal anesthesia alone or combined with gas-oxygen. In general, we believe that a rapid pulse is of no great significance in these cases as long as it remains regular and of good quality.

The respiratory rate is of great significance to the anesthetist, as it is readily influenced by barbituric compounds. In no case did we observe any

slowing of respiration which would indicate a toxic effect of the anesthetic upon the respiratory center. Neither did we notice any mechanical disturbances of respiration due to paralysis of the masseter muscles and "drop of the jaw" as reported by Menegaux and Sechehaye and Jarman and Abel.[18] No apnea occurred in our cases. We had no asphyxial phenomena, due to mechanical obstruction of the glottis by mucus, because in all of our cases with excessive expectoration we used the author's intratracheal catheter.

Respirations as a rule were faster by ten to 20 a minute at the end of the operation than at its beginning. In cases in which no additional anesthetic was given we were impressed by the regularity of both rhythm and depth of respiration and of the slight influence upon them of the rather wide variations of blood pressure and pulse rate. During operations upon the chest the rate and, more especially, the rhythm and depth of respiration are our most valuable guides. It is our impression that in thoracoplasties under Evipal anesthesia we had more satisfactory respiration than with general anesthesia, either alone or combined with avertin.

Complications.—In 100 operations analyzed we did not have any serious complications either during or after operation. Slight cyanosis occurred in seven cases and was rapidly relieved by oxygen-carbon dioxide inhalations. Tremor developed in 11 cases; in five it was very slight and lasted only a few seconds; in one it was limited to the left upper and lower extremities; in one in the left hand, and in another it was generalized. In three cases tremor lasted about one minute.

Slight cough denoting irritation of the larynx and trachea was noticed in seven cases. It ceased as the patient became unconscious.

Apnea was not observed in our cases, either from toxic action of the drug upon the respiratory center or from mechanical obstruction of the larynx by the drop of the jaw. In no case have we noticed either hiccough, extreme pallor, or impending asphyxia.

No important postoperative complications developed. However, restlessness, which is very frequent following anesthesia with sodium amytal or avertin, was noticed in 23 cases, in eight of which it was rather marked but of short duration. Injections of coramine and strychnine had allayed the restlessness in all but two cases; these required an injection of pantopon. We have used pantopon with satisfaction together with strychnine as advised by Cailleret[5] and more recently by Duboucher,[13] who gives routinely 0.01 Gm. of strychnine at the end of the operation. The percentages of restlessness in our cases was 23 per cent, more in agreement with Sailer[29] and Pauleit[26] (15 and 21 per cent) than with the majority of authors who claim only 2 or 3 per cent. However, Duboucher[13] notes 30 per cent before the use of strychnine.

Vomiting developed in 39 cases. There is no doubt that Evipal itself causes postoperative vomiting because in 14 of these cases no additional gas-oxygen anesthesia was used. However, of six cases which had repeated vomiting only two had had Evipal anesthesia alone, whereas the other four

had had supplemental gas-oxygen. In 42 cases in which only Evipal was used vomiting occurred in 16 cases (39 per cent); in 58 cases in which additional anesthesia was used vomiting was noted in 23 cases (40 per cent). In all but six cases there were one to three vomitings following operation, causing no disturbance to the patient. It is probable that Menegaux and Sechehaye[23] who reported only 2 to 3 per cent of vomitings have considered only cases with severe vomiting, unless we must attribute our higher percentage to the pantopon given before operation.

Shock occurred in six cases. None was apparently due to the anesthetic, and all but one recovered shortly after operation. As previously stated, complete consciousness returned within from 32 minutes to a few hours. Anesthesia was followed by complete amnesia, which is certainly most gratifying to the patient.

There was no complaint of headache. Thirst was always present. However, the routine intravenous injections of 500 cc. of 5 per cent sodium chloride immediately following operation undoubtedly played a rôle in producing thirst.

Morbidity and Mortality.—Postoperative pulmonary morbidity has greatly decreased by this method of anesthesia; the persistence or, at any rate, the rapid reestablishment of the cough reflex helped to prevent the occurrence of pulmonary complications. One death, only, occurred in these 100 operations. This was due to operative shock.

In a general way, in this series with Evipal anesthesia the postoperative course was markedly more smooth than that following any other anesthetic used thus far.

Although we have been particularly fortunate with the employment of this anesthetic, we must not disregard the fact that a number of serious accidents and even deaths have been reported by others. Menegaux and Sechehaye have collected 49 cases in which serious accidents followed the use of Evipal, without terminating in death and 22 cases in which death occurred. In ten of the latter autopsy was performed.

Accidents Without Death.—In 42 of the 49 cases, the accidents observed were apnea, Cheyne-Stokes respiration, shock and cardiac failure. In other words, 85 per cent of all accidents were cardiorespiratory complications. In four cases prolonged sleep lasting from three to ten hours was observed. In one case with prolonged sleep for ten hours a diagnosis of "hepatic coma" was made. This patient had an obstructive jaundice. In 20 cases the time of occurrence of the accidents was reported; in 18 of them (90 per cent) the accident occurred immediately within one to five minutes following injection. In one case of mastoiditis three arrests of respiration occurred shortly after awakening. In one, signs of meningitis occurred on the third day, without any pathologic changes being found in the spinal fluid. All of these recovered by means of artificial respiration and the use of oxygen-carbon dioxide inhalations, lobelia, coramine and icoral. It is difficult to assign a definite cause to these complications. In 19 (38 per cent) there

was a general sepsis or pronounced toxemia. In two patients who were in good condition apnea occurred following injection of large doses of 16 to 20 cc. of the 10 per cent solution of Evipal. Of the three cases in which prolonged sleep was observed, two had obstructive jaundice, and one had acute yellow atrophy.

From the study of the above cases we can draw the following conclusions: that advanced lesions of the liver constitute definite contra-indications to the use of Evipal, although in these cases any anesthetic is dangerous. This holds true also in cases with advanced sepsis or toxemia such as follows prolonged intestinal obstruction. The most frequent accidents are related to the respiratory centers. This fact should always be borne in mind and an overdosage, or a very rapid injection of Evipal, should be carefully avoided. Almost all of the cardiorespiratory accidents mentioned above occurred immediately after injection and were readily relieved by artificial respiration and oxygen-carbon dioxide inhalations.

Accidents Followed by Death.—An analysis of the 22 lethal cases reported shows that in 18 (82 per cent) there was a marked degree of sepsis or toxemia, such as Ludwig's angina, gangrenous phlegmon of the chest wall, generalized peritonitis, *etc.* In only three cases may Evipal be considered as responsible for the death. However, in one of them, a patient upon whom cholecystectomy was performed, 15 cc. of the 10 per cent solution of Evipal were given and death occurred the next day; furthermore, there was a temperature of 104° F., which indicated an operative rather than an anesthetic death. More puzzling is the case of a male patient of 60, operated upon for hydrocele, reported by Duboucher,[13] to whom only 8 cc. of Evipal were given. This patient died 22 hours after operation with signs of uremia, *i.e.*, hypothermia, slow respiration and drowsiness, alternating with deep sleep. Since we know of no clinical or experimental cases in which renal lesions have been produced by Evipal, we agree with Menegaux and Sechehaye that we must attribute this death to nephritis and uremia rather than to Evipal. In the second case, reported by Hövelborn, death with respiratory arrest occurred four and one-half hours after operation. The report of this case is incomplete and no definite conclusions can be drawn. The third case was a man of 79, with a strangulated hernia, who died 12 hours postoperatively; immediately after injection this patient presented symptoms of apnea, which were relieved; here again it is difficult to be certain that this death was due to Evipal. On the other hand, however, there are a number of deaths which apparently are due to Evipal. The results we have obtained thus far do not permit us to accept the unfavorable opinion of Desplaas[12]; on the contrary, we feel strongly in favor of Evipal. However, the precautions in the technic of administration mentioned should be strictly observed if we are to be fair in our conclusions.

Prevention and Treatment of Accidents.—As stated previously the principal dangers in Evipal are toxic effects upon the cardiorespiratory centers, prolonged sleep and retarded or defective destruction of the anesthetic in the organism.

To avoid the first danger three preventive measures are necessary and sufficient: limitation of dosage to 10 cc. or less in one injection; second, slow injection, that is, a minimum time of one minute and 15 seconds for 10 cc., and third, the use of ephedrine immediately before the administration of Evipal, in order to counteract the initial drop of blood pressure. The other two dangers are connected with hepatic lesions and advanced degrees of sepsis; both contra-indicate the use of Evipal, because they hinder its oxidation and destruction in the liver.

Although we do not possess any real antidotes to the barbituric compounds, we have, however, a number of drugs with marked antagonistic properties to them. These are strychnine, cocaine, picrotoxin, coramine, icoral and alcohol.

Strychnine.—Haggard and Greenberg,[17] and later, Duboucher[13] and his collaborators, stated that strychnine was an antidote to barbituric acid. Dogs to which several times the lethal dose of barbituric had been given were resuscitated by using lethal doses of strychnine, and vice versa. But Chauchard[6] has shown lately that this antagonistic action does not exist, in reality; but it is because of the powerful stimulating properties of strychnine upon the central nervous system and especially of the medullary centers, that this drug counteracts the depressive action of barbiturates upon these centers.

Cocaine.—Maloney[22] has shown that cocaine is a strong antagonistic to barbiturates; however, although the former may prevent cocaine poisoning, the use of cocaine against toxic phenomena, due to barbiturates, is far from being regularly efficient.

Picrotoxin.—This alkaloid, which is a powerful stimulant of the medullary and spinal centers, seems to be the most active antagonist to the depressive action of barbiturates upon these centers. Maloney reported that experimentally he was always able to stimulate respiration and resuscitate animals poisoned with barbiturates, provided the heart was still beating. This substance appears to be the most efficient agent in cases of cardiorespiratory accidents due to intoxication by barbiturates.

Alcohol.—The use of 50 to 100 cc. of alcohol in 20 per cent solution intravenously seems to have a very favorable action against barbituric poisoning. These injections can be repeated if necessary (Carriere[4]).

Coramine—Escorine.—The advantage of coramine is that it is perhaps as efficient and much less toxic than strychnine (Carriere[4]). Large amounts of coramine should be used, usually 5 to 10 cc.; 40 to 50 cc. in one hour, intravenously, have been well tolerated. Ecorine (Icoral, Bayer) is considered even more potent and efficient than coramine; Menegaux and Sechehaye have used it in cases of postoperative shock with gratifying results.

Thus it would seem that strychnine, coramine, escorine, alcohol and, of course, oxygen and carbon dioxide are powerful agents in stimulating respiration in barbituric poisoning. These drugs have the advantage of being easily administered. The most efficient antagonist of barbiturates seems, however, to be picrotoxin, the use of which is limited because of its toxicity.

CONCLUSIONS

(1) Evipal is a barbituric compound, which is almost completely (97 per cent) destroyed in the organism and is very rapidly eliminated. Its hypnotic action is practically instantaneous; the duration of anesthesia is short (10 to 30 minutes, with the administration of 1 Gm.).

(2) Rapid destruction and elimination of Evipal decreases, to the minimum, the dangers of toxic effects upon the respiratory and vasomotor centers. On the other hand, its action upon the laryngeal and bronchial reflexes is very slight.

(3) The above characteristics recommended this anesthetic agent in thoracic surgery and more particularly in thoracoplasties for pulmonary tuberculosis. One hundred consecutive cases of thoracoplasty are analyzed and the effects obtained are presented.

(4) In a general way the results were very favorable. Although the blood pressure presented a marked drop within one to three minutes and the respiration and pulse were accelerated, there were no untoward effects. Cough reflex and expectoration are rapidly restored after operation. Furthermore, intratracheal suction during operation by means of an intratracheal catheter was facilitated by this method of anesthesia.

(5) The physiologic, physiochemical and pharmacodynamic characteristics of Evipal are described.

(6) The antidotes and antagonistic substances are mentioned and the prevention and treatment of toxic complications are discussed.

(7) Only the effects of a single dose of Evipal, given intravenously, are reported.

(8) We have been greatly pleased with this anesthetic. Operative shock and postoperative complications have greatly decreased, the postoperative care was simplified and the patients have manifested a marked preference to this anesthesia over all other anesthetic methods used before. This last point is of great importance with patients who, usually, have to have repeated operations.

(9) Notwithstanding the obvious advantages of Evipal and our favorable results, it should not be forgotten that, like all barbiturates, Evipal is a toxic substance. A number of accidents have been reported.

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LOCAL PROPHYLACTIC USE OF ANTIGAS GANGRENE SERUM*

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AN APOLOGY is perhaps in order for the presentation of what may be designated as a preliminary communication, although the clinical report which forms its major part is based upon a considerable experience. It is hoped that the recitation of the observations which have been made relative to the prophylaxis rather than the actual treatment of gangrene resulting from wound infection may be considered of sufficient importance to warrant the use of this procedure.

Gas gangrene, so called, became of outstanding importance as a surgical problem during the World War and it was one of the causes of the high mortality. Because of its danger, treatment was begun before bacteriologic proof had been furnished.

Although there are other well known organisms which produce gas when they infect the tissues, the clostridium welchii or, as the French call it, perfringens, has been the one which has been principally studied. In order to prove the presence of exotoxin and the production of antitoxin, Bull and Pritchett[5] infected the pectoral muscles of pigeons. One side was left untreated, and the other which had been equally infected they treated by injecting antiserum. The results were most impressive. The untreated infected side showed in a few hours the characteristic swelling, discoloration and crackling of this form of gangrene, the opposite muscle remaining absolutely normal.

You probably all know of the methods of therapy used during the War. Here we received the patient already infected and usually with fully developed gangrene. It was found that in spite of the local use of antiserum, that of Bull, Weinberg of the Pasteur Institute, and others, few if any favorable results were obtained, especially in the far advanced cases. In order to save a limb or perhaps a life it was necessary to extirpate the entire muscle even though there was visible contamination in only a small area. For example, I have seen more than once an entire quadriceps extensor muscle removed because of a small patch of apparently localized gas gangrene. Under this treatment many lives and limbs were saved but, naturally, with great resultant deformity and disability. It was pretty well recognized that although gas bubbles usually appeared in the areolar tissue, especially beneath the skin, the skin itself was not often the seat of spreading gangrene of this type, though other forms of foul necrosis do affect the skin. Still, the usual excision of diseased parts was performed. Of greatest importance would be a method for preventing the development of gangrene when infection is already present. And

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this was of particular consequence in wounds of parts which could not be treated by the radical surgery to which I have referred; for example, wounds of the chest wall. Here attempts were made by intravenous injections of Weinberg's serum but, so far as I could see, with little if any result.

On my return from the War I was anxious to make clinical experiments looking toward the prevention of the terrible gangrene of the chest wall, not always of the perfringens variety, after operations for suppuration of the lung. In looking over my records of the lobectomies of years ago, I found that even in the patients who recovered there had been a stage of spreading gangrene of the chest wall which gradually became limited after the casting off of sloughs.

In 1922, Professor Weinberg was kind enough to send me a generous supply of his antigas gangrene serum for intravenous use before operation as well as after. I used it in a number of cases but with no visible prophylactic effect. It then occurred to me that perhaps the local application of serum to the freshly incised thoracic wall immediately after operative evacuation of a putrid abscess of the lung might prove to be efficient.

In 1930, I began the systematic employment of this therapy. I am able to report that in nine operative cases of intrathoracic fetid suppurative disease, and one case of true gas gangrene of the leg, there was not a single visible postoperative anaerobic infection of the muscles or skin.

The usual surgical procedure in abscesses of the lung is to perform a preparatory operation whenever the infected region is not adherent to the parietal pleura, so as to minimize the danger of infecting the free pleural cavity. Whether in one or two stages, when the abscess is opened, drainage of some sort is carried out, either by tube, gauze, or both. In nearly all cases, infection of the muscular chest wall occurs, and often this causes more trouble than the mere drainage of the abscess. I determined to prevent this infection if possible by the local use of large quantities of mixed antigas gangrene serum. Having placed the drainage material into the abscess cavity, I completed the dressing by packing the entire wound of the chest wall from the abscess to the surface, with gauze saturated with the serum. This was placed in the form of a doughnut packing, leaving an opening for the deep drainage. At the early subsequent dressings this serum impregnated gauze was not disturbed and, when at the end of five or six days the doughnut was no longer adherent to the chest wall it was removed, leaving a perfectly clean, healing surface, with areolar septa sealed. From now on the abscess was treated in the manner best suited to the individual case but, in spite of the still present anaerobic organisms, no infection occurred in the chest wall. And even when other abscesses developed in the depths and were evacuated through the same opening, the fresh, virulent infection from these hitherto undrained pockets did not infect the healing, granulating wound of the thoracic wall. I have not seen any systemic effect ascribable to the serum such as serum sickness or urticaria, and the danger of this complication may probably be disregarded because no intravenous or other injections are made.

I have used the sera of several manufacturers, Lilly, Lederle, Sharp and

Dohme, Parke Davis, and others. There seems to be no difference in action; there are, however, some antitoxic sera made in high concentration. In only one instance have I employed the concentrated serum; in all the others I have used the ordinary product known commercially as antitoxic sera. Dr. Gregory Schwarzmann, of the Mount Sinai Hospital laboratory, suggested that an investigation of the antitoxic power of normal horse serum would be in order, saying that most horse sera had some antitoxic quality. He even advised that I should use as a control some cases in which ordinary horse serum sterilized by heat would be used in place of the gas gangrene serum, and he was kind enough to supply me with a quantity of this fluid. I made use of it in one case, a secondary operation. While there was no actual gangrene of the tissues there was infection with the appearance of the usual purulent exudate instead of the perfectly clean wound surface seen after the use of antitoxic serum.

The histories of two typical cases are presented, one of pulmonary abscess treated in this way and one of traumatic gas gangrene of a lower extremity. A brief résumé of other cases is also appended.

One objection which has been raised has to do with the price of the product. I maintain, however, that this may be counteracted by reduction in the time and expense of hospitalization.

CASE REPORTS

Case 1.—Mrs. Sophie H., aged 40, presented herself in May, 1933, with a well developed, foul pulmonary abscess following pneumonia and empyema. There was coughing and much fetid expectoration, and it is quite probable that the case had been originally a lung abscess, the empyema being secondary. She was well nourished and in good general condition. The abscess as determined roentgenologically was about the size of a small orange, and was at the level of the fifth rib posteriorly. She was operated upon at Mount Sinai Hospital on May 14, using local anesthesia throughout.

Procedure.—Because of the overdeveloped fat layer beneath the skin, it was not possible to palpate the ribs; but it was my intention to resect the fourth. An incision was made in the anterior axillary line, running downward. It was thought that general adhesions would be present, and this proved to be the case and allowed the opening of the abscess at once. After resecting the rib a large aspirating needle was passed into the lung where it encountered tough tissue nearly an inch away from the surface; it then entered an abscess cavity from which was drawn a small quantity of foul, thick material. The abscess was now opened with blunt dissecting scissors. There was fetid pus and the expulsion of a thick substance which looked much like gangrenous lung. The finger palpating within was unable to discover any secondary pockets but there were trabeculae probably containing vessels; the cavity was packed, because of the fear that a tube however soft might bring about erosion and hemorrhage. A thick packing of gauze soaked with antigas gangrene serum covered the entire wound through the chest wall. There were no sutures.

Six days after the operation the packings within the abscess cavity were replaced by a soft black rubber tube. On removing the packing from the chest wall not the slightest sign of infection was present and this part of the wound healed with great rapidity. The patient was discharged on June 8, 29 days later, convalescent and with no sign of pulmonary suppuration. (Case 5 in Résumé.)

Case 2.—(Case 7 in Résumé.) Mrs. Dora F., whom I saw in February, 1934, with Dr. I. S. Tunick. Six days before in an automobile accident she received a fracture of the

right fibula five and one-half inches above the ankle, with almost no displacement. There was, however, a severe, deep laceration of the leg below the knee with a few neighboring blebs. The patient was also suffering from multiple contusions and from a laceration of the scalp. The wounds had been sutured without drainage. Antitetanus serum had been administered and, the day following the accident, antiperfringens serum as well.

Five days after the injury, Doctor Tunick saw the patient at the Hospital for Joint Diseases, and immediately recognized the characteristic crepitation of gas infection below the wound. She had a temperature of 101.6°F. He at once removed the sutures, and examination of the infected fluid revealed a rapidly growing pure culture of perfringens. The wound was about five inches in length, and there was an area of necrotic and infected skin adjacent to it. Sagittal incisions were made by him at each end of the wound to improve drainage. The following day I saw the patient. Although the general condition was good, her face was pale, with a slightly yellow tinge. Characteristic foul odor was present, and crepitation was distinct and extended to a point four to five inches below the laceration. The foot was somewhat swollen but did not appear to be infected. There was an area about five inches long and three inches wide on the outer surface of the midthigh which was discolored, so that a tourniquet was not applied.

The lacerated and gangrenous skin was completely excised, as well as that surrounding the incision which had been made previously. Complete débridement was performed down to what looked like healthy muscle, so that at the conclusion of the operation apparently only normal tissues were visible. Had I been called upon to treat a case of this kind during the War, the proper procedure would have been to extirpate all the muscles which had been lacerated. Here, however, only manifestly infected muscle was removed. A packing of several layers of gauze soaked with polyvalent antigas gangrene serum of the concentrated type was applied, and placed in contact with all visible parts of the wound. Upon this was laid a piece of oiled silk, and the leg was then encased in thick elastic gauze pads pinned in place—no bandages were applied. There was excellent reaction and next day the temperature was nearly normal.

Seventy-two hours after the operation the wound was exposed. There was no redness, no sign of progressive inflammation, and the subsequent course of healing was most satisfactory.

In all the references consulted there were only two investigators who had made experiments with sterile horse serum, the first nearly 35 years ago. Raymond Petit[16] made some important experiments at the request of Metchnikoff. It may still prove that certain horse sera are inherently antagonistic to the microbes responsible for traumatic gangrene, although, as Schwarzmann has stated, the sera vary greatly in potency. Petit made experiments in prophylaxis in the peritoneum, in the uterus (in puerperal infections), in purulent pleurisy, in phlegmons, and in other wounds healing by secondary intention. The horse serum which he used had been sterilized by heat. The presence of these normal sera he found produced polynucleosis, the cells becoming phagocytic. He employed horse serum because it is ordinarily less toxic than the bovine. It was heated in a water bath for two hours for three consecutive days at a temperature of 194° F. in order to get rid of the alexin. Petit's theory was that the bactericidal quality of the horse serum was secondary, and that the real antiseptic effect was that produced by the induced phagocytosis. He even antedated my observations in regard to the use of serum poured into the opened pleura, employing these instillations every day for several days. Use was also made of powdered serum which he introduced into septic uteri, and in phlegmons by means of gauze impregnated with the

powder. There is no mention made, however, of its use in the *prophylaxis* of combating or preventing the gangrenous infection of tissues adjacent to the infected region, for instance the chest wall; and it is in this connection that I have made my principal clinical experiments. Kling reported experiences with infection of the extremities by the clostridium aerogenes-capsulatum. He made intravenous injections of horse serum in two cases with apparent detoxication and excellent results. This has little to do with the prophylaxis, which is the subject of the present article.

In the cases mentioned below, the antigas gangrene serum was employed with notable success. In no case was there gangrenous or other marked infection of the chest wall:

RÉSUMÉ OF CASES TREATED

Case 1.[10]—1930.—Ignatius C., aged 22, revision of lobectomy. Antigas gangrene gauze was used in this case, but was not specifically mentioned in the published report.

Case 2.—1931.—Dan B., aged 15, lobectomy for old chronic suppuration.

Case 3.—1931.—Anna C., aged 32, foul pulmonary abscess. Several operations. Antigas gangrene serum used twice with no infection of chest wall.

Case 4.—1931.—Sam K., aged 41, lobectomy in two stages. Serum used each time. Excellent effect. No sloughing.

Case 5.[11]—1931.—Sophie H., aged 40, already reported in this paper.

Case 6.—1933.—Benjamin M., carcinoma of left lower bronchus, with bronchiectatic suppuration, left lower lobe. Extirpation of lobe. Case reported in Am. Jour. Surg., New Series, vol. 27, No. 1, p. 50, January, 1935.

Case 7.—1934.—Dora F., case reported in this paper.

Case 8.—1934.—Louis G., foul abscess of lung with pulmonary gangrene. No visible infection of chest wall.

Case 9.—1934.—Joan R., aged 3. Thoracic fistula with foreign body. Extremely foul discharge from sinus of chest wall. Patient septic. Repeated instillation of serum removed all odor in a few days; then operation. Serum used. No chest wall infection.

Case 10.[12]—1935.—H. S., male, aged 50. Fetid lung abscess. Clean pleura unavoidably opened, and antigas gangrene serum poured in through a second wound which had been made for drainage. No acute infection, no odor, clear serum for a number of days, then opalescent. Antigas gangrene serum used during two procedures.

SUMMARY

(1) Prophylactic treatment of healthy structures wounded during operations upon tissues the seat of gas gangrene, is presented.

(2) This has been accomplished by packing the healthy portions of the wound with material impregnated with antigas gangrene serum.

(3) A brief résumé of ten cases is given.

CONCLUSION

Experience with this form of prophylaxis has convinced the writer of its value.*

* In presenting this subject I have made use of the term gas gangrene when the qualifying word might better have been omitted, although one of the case histories was that of traumatic gangrene which proved to be a perfringens infection. In the discussion it was naturally but erroneously assumed that the paper dealt exclusively with gas gangrene. What is really meant is any gangrenous, sloughing, fetid infection of the chest wall.

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DISCUSSION.—DR. FRANK H. LAHEY (Boston) said he would be glad to speak about gas bacillus infections in chest wounds if there had been any, but they had had none. Doctor Overholt, who is in charge of chest surgery, had performed quite a number of lobectomies for bronchiectasis but he felt sure there had been no case in which there was a gas bacillus infection. He was particularly interested, however, in personal experiences with gas bacillus infections following dilatation of the sphincter of Oddi in patients with common duct stones. For some time dilatation of the sphincter of Oddi has been employed in the Clinic by means of what are called Bâkes dilators, this method having been called to his attention by Dr. Arthur W. Allen and which had proved to be quite a useful procedure. The dilators are graduated in size up to 11 Mm. in diameter and when passed through the sphincter leave the opening of the common duct into the duodenum so dilated that any detritis or small stones overlooked in the removal of common duct stones will be washed into the duodenum by the flow of bile. The common and hepatic ducts were opened and explored for stones in the course of gallstone operations in 531 cases. Previous to the employment of these dilators, there had never been a case of gas bacillus infection of the liver in the gallstone cases. Since their employment, however, there have been two fatal gas bacillus infections of the liver, both proven by autopsy and doubtless due to C. welchii ascending the ducts from the duodenum through the dilated sphincter. Doctor Lahey said he was mentioning these two fatalities not to condemn the dilators, because they are very useful instruments, but to warn surgeons concerning the possibility of this complication and to call attention to the fact that there must be a real danger to overdilatation of the sphincter of Oddi. He con-

cluded that he had had little experience with C. welchii infections elsewhere because so large a part of the surgery in the Clinic is of the deliberate type and so little of it traumatic.

Dr. Frank L. Meleney (New York) said that he had been very much interested in the bacteriology of lung abscesses because he has thought that they are very frequently symbiotic infection. It is rather difficult to make a complete bacteriologic analysis of the contents of a lung abscess. If sputum is taken and examined, it is complicated because the pus from the abscess is mixed with all the mouth organisms. But if a culture is taken directly from the lung abscess at operation one may get a fairly good idea of the organisms existing there, some of which may be factors in the infection itself and others just casual contaminators. In looking for gas gangrene organisms 14 cases have been studied carefully and only one case was found in which a gas gangrene organism was present and that was C. welchii. Doctor Cohen has reported 16 cases from Mt. Sinai Hospital but Doctor Meleney did not know whether or not these included any of Doctor Lilienthal's patients. However, in no case did he find any of the gas gangrene organisms. Doctor Varney, in a larger series of 27 cases, found no gas gangrene organisms in lung abscesses. C. welchii pneumonia does occur, but gas gangrene organisms in lung abscess seem to be particularly rare. If it is assumed that they are frequently present and these cases are treated with antigas gangrene serum, the situation will not quite be met. Doctor Meleney asked Doctor Lilienthal if he formerly had any proven cases of gas gangrene of the chest wall following operation for lung abscess. There are polyvalent antitoxic sera put out by several commercial firms, which specifically neutralize the toxins of the gas gangrene organism. These sera should be used in the active treatment of gas gangrene cases or may properly be used as a prophylactic in situations in which gas gangrene is likely to arise; but where gas gangrene organisms are very unlikely to occur Doctor Meleney did not feel that the general use of antitoxin is indicated. His laboratory experience with C. welchii vaccine had been very disappointing in attempts to develop an immunity and agreed, with Doctor Schwartzmann, that horse serum does have an inhibiting action on a number of organisms. The organisms that occur in lung abscesses are largely the anaerobic streptococci, micro-aerophilic streptococci, spirochaetes and fusiform bacilli. The spirochaetes and the fusiform bacilli are not particularly virulent in pure culture but, in association with streptococci, do produce, or at least are found in, the worst cases of lung abscess. To combat those organisms something more is needed than antigas gangrene serum. The best agent in Doctor Meleney's experience was zinc peroxide, which Doctor Moore had recently used in seven cases at the Presbyterian Hospital. This will usually be found effective not only in control of the gas gangrene organisms but also of the anaerobic streptococci, micro-aerophilic streptococci, spirochaetes and the fusiform bacilli.

Dr. Howard Lilienthal expressed his surprise to hear, after having had considerable experience with chest surgery, that gas gangrene in these cases is so very unusual in civil life. He agreed that it is perhaps not quite accurate to use the word "gas gangrene" when really he had meant any gangrenous, sloughing, fetid infection of the chest wall. It can hardly be considered entirely a coincidence, that when formerly he saw sloughing infection of the wall of the chest in practically every case in which a foul lung abscess had been evacuated surgically, and after nearly every case of lobectomy for suppurative bronchiectasis, he can now present ten consecutive cases without any sign of gangrene. By employing, as described, the antigas gangrene serum, there has been no sloughing or visible infection of the chest wall. His work, he stated, has been in a measure empirical.

ACUTE INTESTINAL OBSTRUCTION BY THE PERSIMMON PHYTOBEZOAR

REPORT OF TWO CASES

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THE term bezoar, from the Arabian bazahr, badizahr, and the Persian pad-zahr, pad (protecting) + zahr (poison), meaning counter poison or antidote, denotes any of the various concretions found chiefly in the alimentary organs of certain ruminants. Bezoars were formerly supposed to have remarkable medicinal properties, especially as antidotes to poison. The kind most prized was the oriental bezoar, composed principally of resinous organic matter arranged in concentric layers about some hard foreign nucleus, and found in the bezoar goat and gazelle. The western or occidental bezoar, found in the Peruvian llama, consists chiefly of calcium phosphate, while the German bezoar, from the gemsbok, is composed of interlacing fibers or hairs and organic cementing material.

In man, three types of bezoars have been described: the trichobezoar, or hair ball; the phytobezoar, or vegetable fiber ball; and the shellac bezoar composed of concretions of shellac. The trichobezoar is the most common type and occurs in the stomachs of persons addicted to the chewing and swallowing of hair, while the phytobezoar is the next most frequent variety. Maes,[1] in 1928, was able to collect 116 cases of trichobezoar and 23 cases of phytobezoar from the literature. In Germany, a few instances of shellac bezoar have been reported. These curious masses have been found in the stomachs of patients who had drunk shellac for its alcoholic content, the gummy part of the mixture having been precipitated with the formation of a shellac bolus by the addition of water to the original solution.

Quain,[2] in 1854, described the first case of phytobezoar in man. The mass, composed of cocoanut fibers, was found postmortem in the stomach of a young insane patient, and had caused death by perforation on the lesser curvature of the stomach. Outten,[3] in 1894, was the first to record the occurrence of a persimmon bezoar, and it was not until 28 years afterward that Peple,[4] in 1922, mentioned a second instance. Hart,[5] in 1923, reported eight cases of phytobezoar, six of which were persimmon bezoars; one was of celery fibers, and one of prune and raisin skins. Adams,[6] in 1925, recorded the case of a Chinaman who, at operation, presented a cast of the stomach formed of pumpkin pulp. Bryan's[7] case was that of a man, aged 55, who suffered from abdominal distress and intermittent diarrhea for three years. At operation a soft mass was removed from the stomach consisting of celery fibers and prune and raisin skins.

Of the phytobezoars the persimmon bezoar is by far the most common,

and, since Hart's paper, the number of reported cases has steadily been added to (Upson,[8] Porter and McKinney,[9] Larimore,[10] two cases, Garrett,[11] David,[12] Maes,[1] Balfour and Good,[13] Potter,[35] Camp,[14] Podlasky,[33] subsequently reported by Droegemueller,[15] Lobingier,[16] Cole,[31] four cases, Pollock,[17] Wyatt,[32] Schulze,[18] Smith,[34] two cases, Crossan,[19] Durrance,[36] six cases (five collected from various sources), Henschen[37]).

Phytobezoars rarely cause intestinal obstruction. There are seven reported cases in which these masses have produced acute small bowel occlusion. Of the 37 reported cases of persimmon bezoars, in only four instances has the bolus been found in the intestinal canal. An additional case, probably of a persimmon bezoar, reported by Downing,[20] brings the number of proven and probable obstructing persimmon bezoars to five. In all of these cases, acute obstruction had necessitated surgical intervention. In addition, Wyatt[38] saw one case and O'Bannon[39] saw two cases of small bowel obstruction from persimmon bezoars. Wyatt's case was not reported, and O'Bannon, in discussing Durrance's paper, only mentions the fact.

Simpson,[21] in 1923, cited the case of a girl of 16 who was operated upon six days after the development of acute intestinal obstruction. A preoperative diagnosis of small bowel obstruction from a band or volvulus was made. At operation, a mass four and one-half inches in length and two and three-quarter inches in breadth was removed from the ileum, 16 inches from the ileocecal valve. The obstructing body was stony hard and composed of heather roots and twigs, which the patient had been in the habit of chewing. The patient made an uneventful convalescence.

In the case of Dr. Chas. L. Patton, of Springfield, Ill., (Hart's[5] third case), the patient, a male, aged 38 years, had eaten of chicken, potatoes, cheese, stewed cranberries, and a large amount of celery. The following day he developed a sensation of fulness and pain in the abdomen. These symptoms became intermittent, occurred one to two hours after meals, and were relieved by powders. The patient later developed intermittent obstruction and two and one-half months afterward an exploratory operation was performed. A mass, two by three-quarters by one-half inches, composed of celery, was removed from the ileum six inches above the ileocecal valve. A second mass, formed of similar material, and measuring three by two and one-half by two inches, was removed from the stomach. The patient made a complete recovery.

The case of Dr. Carl Davis, of Chicago (Hart's[5] seventh case), was of a male, aged 55, who had had a gastric ulcer for many years. On one occasion he ate many persimmons and subsequently developed a sensation of generalized ill feeling associated with epigastric pain which subsided in five or six days. Eighteen months afterwards a gastro-enterostomy was performed because of several similar attacks. A preoperative roentgenologic study had revealed a gastric ulcer. At operation no exploration of the stomach had been carried out. Eight months after the performance of the gastro-enterostomy, the patient developed acute intestinal obstruction. At operation a

persimmon bezoar, measuring 7.5 by 5 cm., was found impacted in the jejunum. Enterotomy was performed and the patient made a complete recovery.

Downing,[20] in 1926, reported the case of a female, aged 21, who developed symptoms of acute intestinal obstruction. Twenty-nine hours after the onset of symptoms laparotomy was performed. A rough, black mass measuring 2 cm. in diameter had produced a perforation of the small bowel 30 inches from the cecum. There was an associated acute peritonitis. Enterotomy was performed and the patient recovered completely. The inspissated material dried on exposure to the air and in every way conformed to the physical characters of a persimmon bolus. Its origin, however, was not definitely determined and no mention of the patient having ingested persimmons was given in the report.

Lobingier,[16] in 1930, reported the case of a female, aged 33, who, three days before, had eaten several Japanese persimmons. The patient developed nausea and abdominal cramps. A diagnosis of obstruction was made. At operation a mass was found arrested in the midjejunum. There was marked distension of the bowel. Enterotomy was performed, using a linear incision. The removed specimen consisted of persimmon hulls and measured 4 by 3 by 3 cm. The patient made an uneventful recovery.

Cole,[31] in 1931, mentioned two brothers, aged 75 and 66, respectively, operated on by Dr. Frank G. Nifong, of Columbia, Mo. In Doctor Nifong's first case, the patient had had abdominal pain for six days. A preoperative diagnosis of obstruction was made and at operation a mass, the size of a walnut, composed of persimmon seeds, was found about 24 inches from the ileocecal valve. The first patient's brother, operated on three years later, had developed severe abdominal pain, associated with vomiting, two days before. At operation, a large mass composed of persimmon seeds and pulp was found in the ileum. The subsequent course of these patients is not given in the report.

During the past five years we have had the opportunity to observe two patients who developed acute small bowel obstruction as the result of impaction of persimmon bezoars in the ileum.

CASE I.—Mrs. C. B. F., a white female, aged 50 years, was admitted to the hospital October 23, 1930, complaining of nausea, vomiting, and diffuse intermittent abdominal pains of about 43 hours' duration.

She had been seen by one of us (R. L. H.) in 1926. At that time she complained of gas, discomfort, and crawling sensations in the left side of the abdomen. These symptoms had appeared about two years before, had slowly progressed in intensity, and at times were especially marked after meals. Examination revealed no evidence of organic disease and a diagnosis of probable neurosis was made. These symptoms, however, did not improve, and, in October, 1926, a diagnosis of appendicitis was made elsewhere. A barium meal, at that time, revealed no abnormality of the gastro-intestinal tract. In May, 1927, the patient consulted physicians of the Mayo Clinic who were unable to find any definite evidence of organic disease. Notwithstanding these negative findings, the symptoms continued to increase in severity. She suffered with

much gas, discomfort after meals, and abdominal distension. However, to the present day, the patient denies ever having had any stomach trouble or true abdominal pain.

On the evening of October 21, 1930, after having eaten chili for supper, the patient became nauseated, vomited, and developed intermittent, colicky, abdominal pains. The following morning a diagnosis of probable acute intestinal obstruction was made. However, due to unavoidable circumstances, operation was, contrary to our advice, deferred until the following evening. At the time of admission to the hospital the patient presented evidences of a rather marked obstruction with beginning peritonitis. There was slight diffuse tenderness and rather marked abdominal distension. The leukocyte count was 10,600 with 85 per cent neutrophiles. A barium enema revealed a practically normal large bowel. Laparotomy was performed about 48 hours after the attack began. Under ether anesthesia, the abdomen was opened through a liberal right rectus incision. The loops of small intestine were markedly distended, inflamed, and exhibited many small areas of ecchymosis. There was considerable free fluid in the peritoneal cavity. The appendix was examined and found perfectly normal. The terminal ileum was collapsed and on tracing the gut upward a hard mass the size of a guinea egg was found impacted about 18 inches from the ileocecal valve. Transverse enterotomy was

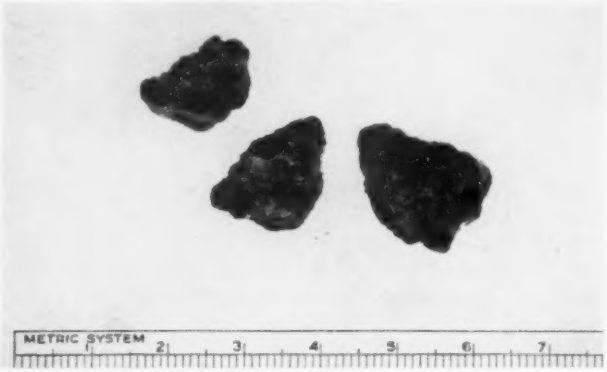

FIG. 1.—Major portions of persimmon bezoar in Case I, which have shrunk to about one-third of their original size.

performed over the mass which was so firmly impacted and closely applied to the intestinal wall that it was of necessity broken up and removed in fragments with the scalpel handle. The gut was sutured with two rows of catgut and covered with omentum. Drainage was instituted because of the associated peritonitis. The patient had a stormy convalescence. Large quantities of saline and glucose were administered intravenously and subcutaneously, and it was necessary to use continuous gastric drainage by means of the nasal catheter. Four days after operation her condition was markedly improved and she was dismissed from the hospital November 11, 1930, 19 days after admission.

The removed particles consisted of tightly compressed persimmon pulp and hulls. The reconstructed bolus was dark brown in color except for a few outer flakes of skins which had retained their orange-red tint. It was roughened on its external surface, and measured approximately 6 by 4 by 4 cm. On exposure to the air the fragments dried and shrank to about one-third their original size (Fig. 1).

Subsequent to the operation, the patient has been entirely free from the annoying symptoms. No doubt all of her previous trouble had been produced by the bezoar. How long it had been present and where it was formed is purely problematic. However, the presence of bits of orange-red skins on the external surface of the bolus indicates that at least this portion had been of comparatively recent origin.

On further questioning, the patient stated that all of her life she had been very fond of wild persimmons. In childhood she had partaken of them on numerous oc-

casions. She remembered vividly of having eaten, on one occasion, in the fall of 1915, large quantities of this fruit. Almost every fall thereafter friends would send her persimmons, and she recalls having eaten them from a neighbor's tree in the late years of her illness. The patient, however, stated that persimmons had never made her sick and that she had never been able to associate them, in any way, with her symptoms.

CASE II.—H. B., a policeman, aged 34, had, for two years, experienced attacks of abdominal pain lasting from a few minutes to an hour or more. These attacks, at first placed at intervals of a week or longer, had gradually become more frequent.

On the morning of December 25, 1934, he was taken with a severe seizure. He took an enema and passed a portion of material about the size of half an egg. The intermittent abdominal pains continued, and he was admitted to the hospital shortly afterward. Examination, at that time, revealed nothing of significance. During the day the leukocyte count, taken on three occasions, was 9,200, 11,000, and 10,000. The symptoms became less severe; however, during the night, he vomited on one occasion. The following morning the pains again increased in frequency. There was much belching and the patient vomited twice. The abdomen was slightly distended and a point of tenderness just below and to the right of the umbilicus was elicited by pressure over the left side of the abdomen. The leukocyte count was 19,200. A diagnosis of acute intestinal obstruction was made.

FIG. 2.—Persimmon bezoar in Case II. Photograph taken soon after removal.

Twenty-eight hours after the onset of the attack the abdomen was opened, under ether anesthesia, through a right rectus incision. Some loops of small intestine were distended and red, while others were collapsed. There was little free fluid in the peritoneal cavity. The appendix was found normal and was not disturbed. On tracing the collapsed ileum upward a firm mass the size of an egg was found impacted in the ileum about five feet from the ileocecal valve. The gut above was markedly distended. The obstructing body could be moved up and down in the intestine for only a short distance. Transverse enterotomy was performed, the foreign body removed, and the opening closed with two rows of catgut. The abdomen was closed without drainage.

The patient made an uneventful recovery and was dismissed from the hospital eight days after operation. He has had no further trouble.

The obstructing body (Fig. 2) composed of persimmon hulls and pulp, was roughened, dark brown in color, showed a few red skins on its external surface, measured 5 by 3 by 2.5 cm., and weighed 17.7 Gm.

The patient had eaten persimmons for many years, but only on a few occasions had he taken many at a time. During the fall of 1932 and 1933 he ate much of the fruit. On December 9, 1934, while hunting, he ingested many persimmons. That afternoon he ate chili and during the night developed nausea which lasted for two or three days. He attributed this sickness to the chili, for two other people who had eaten the chili with him also became ill. He had never eaten persimmons before that made him sick. On December 16, nine days before the acute attack began, he again ate a considerable quantity of persimmons while hunting.

Food, chiefly fruit, has occasionally produced intestinal obstruction. In nearly all the instances the patients failed to masticate the food properly, either due to haste or because of deficient dentition.

Willmoth,[22] in 1921, recorded four instances of obstruction of the intestinal tract from ingested food; one from potatoes, two from grape hulls and seeds, and one from popcorn. All of these patients recovered following repeated enemas, and in none was operation performed. Alexander,[23] in 1924, reported the case of a man who presented an obstruction a few inches above the ileocecal valve due to a large fig which had been swallowed whole. Another of Alexander's patients suffered from a very acute obstruction of the jejunum produced by a large raisin which had been swallowed intact in the course of eating raisin dumpling. Bryan,[7] in 1926, cited the case of H. O. Koefod, of Santa Barbara, Calif., of a boy, aged six years, who died from intestinal obstruction produced by a large bolus of coarse vegetables in the lower ileum. Chalmers,[24] in 1927, reported a second case of a whole fig impacted in the ileum of an edentulous man. Ackman,[25] in 1929, cited the case of a boy of seven years of age who at operation presented a pint of cherries impacted in the lower ileum. Wardill[26] and Gage[27] have seen small bowel obstruction from pieces of potato.

Elliot,[28] in 1932, collected, from the literature, 39 cases of intestinal obstruction caused by food, none of which was produced by persimmons. In his case, ileus was produced by a mass of orange pulp and seeds impacted in the lower ileum. Block,[29] in 1933, reported an additional case of obstruction of the lower ileum from orange pulp in an edentulous person. In both Elliot's and Block's cases the obstructing material had formed soft bulky masses and the obstruction came on soon after ingesting the material. It seems desirable not to classify the cases of Koefod,[41] Elliot,[28] and Block[29] as phytobezoars, but as impactions of food, therefore they have not been included in the cited reports of bezoar obstructions.

Mushrooms, beans, oats, corn, poppy seed, sauerkraut, gooseberries, and bran have occasionally produced obstruction (Elliot).

Although persimmon bezoars are much more frequently observed than the number of reported cases would indicate, yet obstruction to the bowel by them is indeed rarely encountered. It seems evident that most persimmon bezoars of any size are formed in the stomach, and that they are usually produced after eating the fruit on an empty viscus, the acid coagulating the pulp and juice which contain a high concentration of pectin and gum (14.1 per cent[30]). Whether persimmon bezoars are at times formed in the intestinal tract seems less certain.

In the two cases reported, the patients had for some time suffered with vague abdominal symptoms undoubtedly due to bezoars. In our first case there is no history of an acute gastric upset, following the ingestion of persimmons, so frequently obtained from patients with gastric bezoars. Probably the bezoar had been present in the intestinal canal for many years, for fluoroscopic examination of the stomach, made in 1926, showed no evidence

of a foreign body. Contrary to the usual teaching that bezoars are formed at one sitting, the presence of red skins on the external surface of the bezoar in Case I strongly indicates that the original bolus had been added to. The patient in Case II gave the characteristic history of eating persimmons while hunting and developing an acute stomach upset. This patient probably had had another bezoar of long standing which he expelled after taking an enema on the morning of his last attack. This explains the long history of abdominal colic, the presence of a relatively recent bezoar producing the obstruction, and the acute stomach upset 12 days before.

It is interesting to note in the five cited cases of intestinal obstruction from phytobezoars, in which the postoperative course is given, and in the two additional cases which we have reported, that all of the patients recovered. In both our cases a diagnosis of acute small bowel obstruction was made preoperatively; however, the exact nature of the obstruction was not known until afterward. So many people in this part of the country give a history of eating persimmons that this is of little aid in making a diagnosis of persimmon bezoar obstruction. Furthermore, in Case I, it was very difficult to obtain a history of the patient having eaten persimmons, even after the true nature of her condition had been demonstrated.

The occasional occurrence of obstruction in these cases has suggested to Potter[40] the inadvisability of manipulation and breaking down of a stomach bezoar as a method of treatment.

In both of our cases the bezoars were formed of the pulp and hulls of the wild Texas persimmon (diospyros texana).

SUMMARY

Of the various types of phytobezoars, the persimmon bezoar is the most common.

Persimmon bezoars are usually found in the stomach; however, in exceptional instances, they may pass into or be formed in the intestinal canal and produce acute small bowel obstruction.

Persimmon bezoars constitute one of the least frequently encountered causes of obstruction by food.

The prognosis in cases of phytobezoar obstruction seems to be very good, for, in the five reported cases of acute small bowel occlusion by these masses, in which the subsequent course is given, and in the two additional instances of persimmon bezoar obstruction which have been given, all of the patients recovered following enterotomy and removal of the obstructing bolus.

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TRANSVERSE INCISION IN THE UPPER ABDOMEN

ITS ANATOMIC AND PHYSIOLOGIC ADVANTAGES

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THE recent history of the transverse incision, both infra-umbilical and supra-umbilical, has been repeatedly reviewed. Mention will be made only of those connected preeminently with the first use of the incision. The transverse abdominal incision is not a recent procedure. In 1798, a cesarean section was performed through a transverse opening. In our own day, Rapan, in 1894, Kustner,[10] in 1896, Hartman, in 1900, and Pfannenstiel,[20] in 1900, employed new types of transverse incisions in the lower abdomen. Their success, no doubt, inspired more extensive experiment with the incision and its use in upper abdominal surgery.

Langenbuch,[11] in 1882, removed a gallbladder through an L-shaped incision, and was apparently the first to cut the upper abdominal wall across. Maylard,[13] in 1898, is accredited with performing a stomach operation through the first transverse incision piercing the entire thickness of the wall. In Europe, among those who have had noteworthy results from a transverse incision of original design are Sprengel,[30] Perthes,[19] Bakes,[1] and Konig.[9] In America, Moschcowitz[18] sponsored a somewhat radical procedure, and C. U. Collins,[4] Souther,[29] McArthur,[14] Quain,[22] Sloan,[27] Mason,[12] Singleton,[25, 26] the Bartletts,[2] Schwyzer,[24] and others, have offered modifications. The method as developed by all these operators has differed in some degree, more or less, from those presented previously.

The opinion that the transverse incision, in a certain group of cases, is superior in practically every respect to other types seems to be rapidly gaining ground. Some well known surgeons still cling to the vertical opening, but the results of the transverse incision have been so gratifying in the experience of many of us that we are inclined to wonder if the advocates of the former have given the latter a fair trial.

The transverse incision, like other operative procedures, has gone through a process of evolution, as it were. The pioneers cut across only the superficial layers of the abdominal wall, merely for the cosmetic effect, or only a small part of the incision was made transversely, the major portion having been longitudinal. Then, a few surgeons curved the incision to correspond to the contour of the costal arch. Others combined the straight transverse with a vertical, an oblique, or a curved line, according to the individual conception of the most suitable opening for a particular operation. All have tried to find a technic which would preclude objections and approximate as nearly as possible the anatomic ideal. Various defects, however, have been found in each method in turn, but, almost without exception, the surgeon

who has used the transverse incision to an appreciable extent has been pleased with the results, whatever the technic.

A short discussion of some of the more modern and more popular types of transverse incision will be prefaced briefly by a description of the anatomy of the abdominal wall. The supportive structures of the abdominal wall consist of three lateral and two median muscles, their respective sheaths, and the linea alba. The lateral muscles, the external and internal oblique and the transversalis, are long and flat, with fibers running the direction of their length. Their aponeurotic continuations separate around the rectus muscles

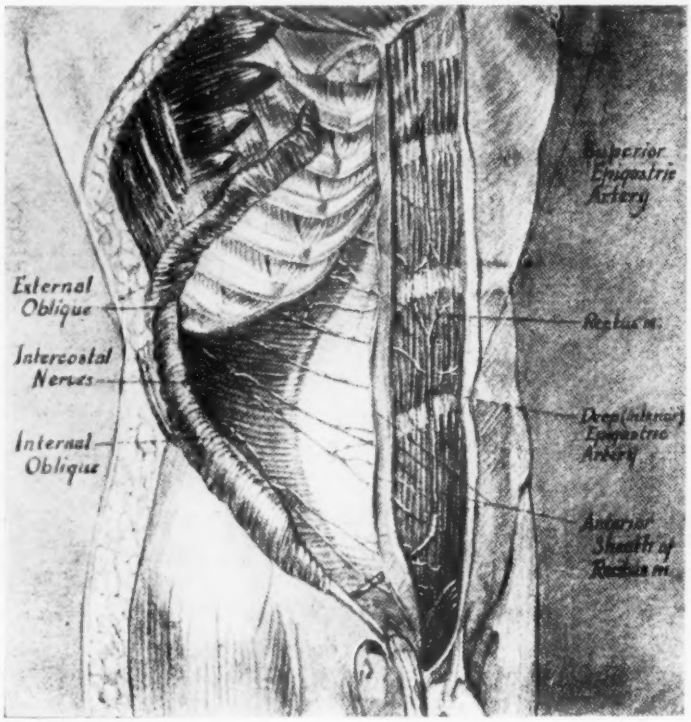

FIG. 1.—Anatomic drawing showing the position of nerves and blood vessels in the abdominal wall. (By courtesy of Dr. A. O. Singleton.)

to join again at the midline in a thick, single layer structure, the linea alba. These muscle sheaths play an essential part in preserving the strength and function of the wall.

The rectus muscles are divided into segments by the linea transversae, which attach the muscles to the anterior aponeuroses. As the linea transversae seldom extend through more than half the thickness of the muscles, on their posterior sides the muscles are less firmly attached to the posterior aponeuroses. Apparently, this division of the muscles into segments provides intermediate points for force and resistance, permitting varying degrees of abdominal tension in the different portions of the abdomen.

The blood vessels of the midportion of the abdominal wall run, for the

most part, longitudinally. The more important, the superior and inferior epigastric arteries, are found on the posterior aponeuroses adjacent to the recti. To the side, their course becomes transverse, corresponding to that of the intercostal nerves. Severance of these vessels presents no especial problem in closing a transverse incision.

The abdominal muscles derive their nerve supply from the seventh, eighth, ninth, tenth, and eleventh intercostal nerves, the subcostal nerve, the inguinal, and the hypogastric branches of the iliohypogastric nerve. Their direction conforms to the lines of the muscle fibers and extends forward and inward. Vertical incision, therefore, necessarily cuts one or more of the nerve trunks, producing atrophy and weakening of the muscles and, in some cases, subsequent postoperative hernia.

In devising a new type of transverse incision or in modifying one already known, each surgeon has taken into consideration these salient features of the wall structure. Their views as to the least harmful and most effective approach, however, have differed somewhat. The points of difference are worthy of discussion.

Moschcowitz, following the plan of Sprengel and Bakes, and making one incision entirely through the abdominal wall, severed one or both recti completely, depending upon the operation to be done. He sutured them to the anterior sheaths to prevent retraction, permit better end-to-end closure, and to insure hemostasis. This, he stated, gave excellent exposure and obviated the necessity for bulky packings. He did not see any harmful effects of cutting the muscles in 67 patients observed from a few months to almost six years postoperatively, and believed the firmly healed peritoneum and aponeuroses, and the small, firm cicatrix at the union of the muscles, with their unimpaired nutrition and nerve supply, offer sufficient guarantee against the development of hernia.

Critics of this method say the scar is likely to become weakened from prolonged stretching, atrophy of the recti adjacent to the incision is a possibility, and there is danger of postoperative hernia, even after the lapse of years. It is said, also, that, since the rectus muscles hold stitches badly, "dead space" may be left in the line of incision, giving rise to the development of an hematoma and infection.

Quain has performed 500 operations on the biliary tract and stomach through a straight transverse incision involving partial severance of the rectus muscles. He reports one postoperative hernia, which occurred as a result of extensive drainage of an empyema of the gallbladder, and which was cured spontaneously. He also had one rupture of a wound in a patient with a complicating bronchitis. There was no loss of life consequent upon the incision. Since his procedure is similar to that of Moschcowitz, it has been open to practically the same criticism.

Mason joins two short vertical incisions, one to the left and above the umbilicus, the other to the right and below the umbilicus, by a transverse incision through the linea alba. Both rectus muscles are retracted laterally,

and the transverse portion of the incision is overlapped when closed. This offers access to a large portion of the abdomen and is suitable for a number of surgical procedures. His idea of preventing hernia by short incisions is a good one, but by this technic one is confronted with the doubtful outcome of closure of the wall at two right angles.

Sloan presented an innovation in upper abdominal incisions when he advocated a median vertical opening down to the fascia. The skin and fat were widely dissected and a paramedian vertical incision was then made through the anterior sheaths of both recti. The muscles were retracted laterally and

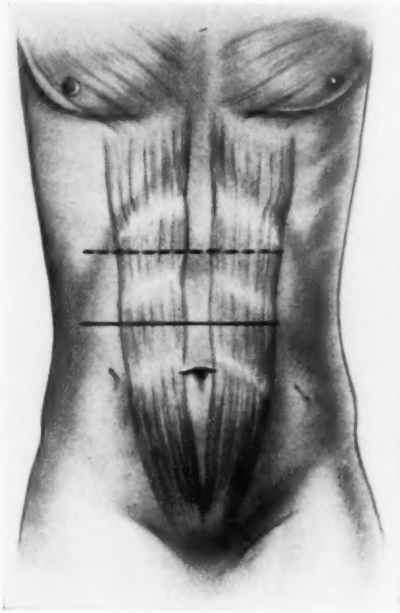

FIG. 2.—Showing that the incision may be made at various levels, according to the width of the costal angle.

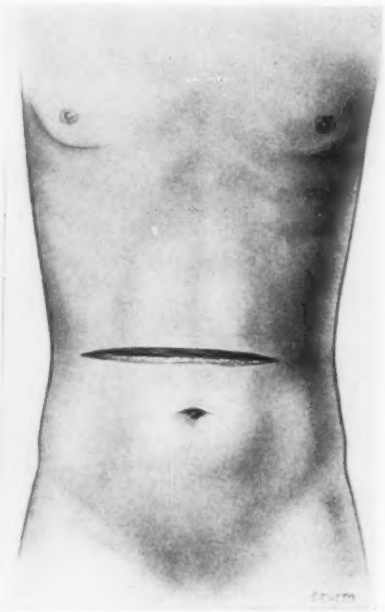

FIG. 3.—Showing transverse incision down to anterior rectus sheaths. For operations on the biliary tract, it is slightly longer to the right of the midline. For splenectomy, extension should be to the left.

the posterior structures divided in a transverse direction. He commended this procedure for exposure of the operative field and preservation of the nerve and blood supply. Further, he stated that it eliminates danger of wound infection, prevents postoperative adhesions, and is easily closed. He offered the criticism himself that the combined vertical and transverse openings involve too much cutting in opening and the expenditure of too much time in closing. It may be said, also, that by this method a large, loose space is created between the superficial fat and the anterior sheaths for the accumulation of serum.

Singleton opens the skin and fat transversely, then dissects them widely from the anterior sheaths up and down, especially on the right. The anterior sheath over the right rectus is incised vertically and the muscle retracted. A short transverse opening is then made over the left rectus to afford ample

retraction of the muscle. The entire posterior wall is separated transversely. This permits excellent exposure.

Singleton admits that his extensive detachment of the superficial tissues

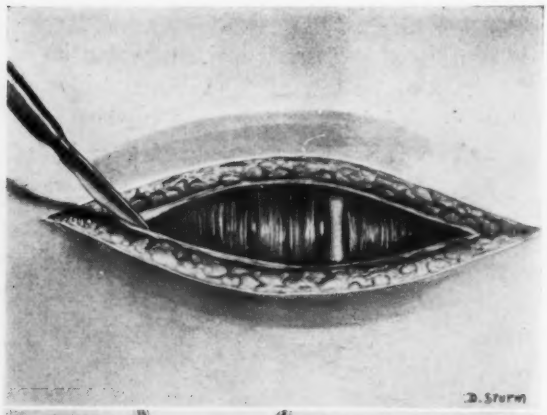

FIG. 4.—Showing the incision extended through the anterior sheaths of the recti and dividing the linea alba.

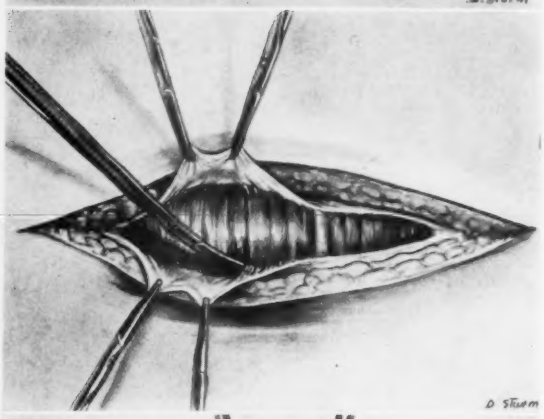

FIG. 5.—Showing separation of anterior sheaths above and below from their attachments to the muscles.

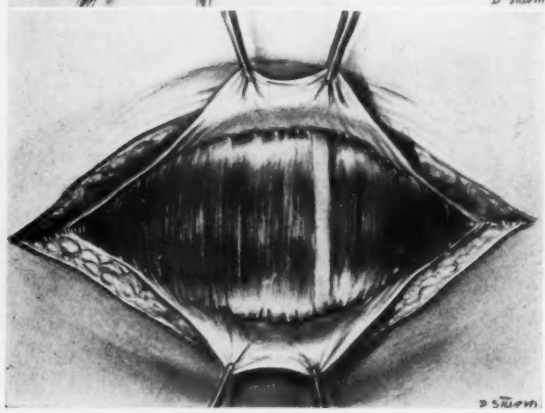

FIG. 6.—Showing separation of the sheaths and muscles completed, ready for lateral retraction of the muscles.

creates a "dead space," as in Sloan's procedure, and predisposes to the collection of serum. This may be absorbed or may, on the other hand, become infected and demand drainage.

The Bartletts propose a "staggered" transverse incision. They open the skin and fat in one layer, the anterior sheaths alone a little higher, the recti at a level below the first incision, and the posterior sheaths on a plane with

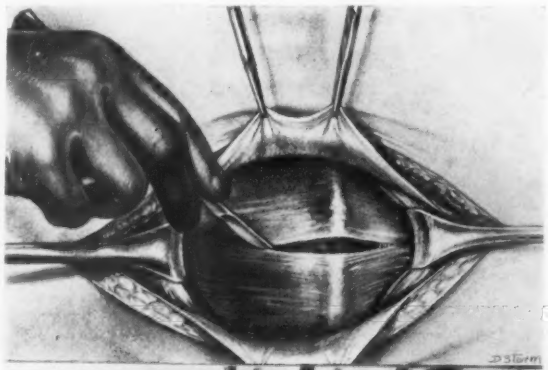

FIG. 7.—Showing recti retracted wider to right. The aponeurotic fibers of the posterior sheaths are being separated and the linea alba divided.

FIG. 8.—Showing peritoneum open and falciform ligament being divided between clamps.

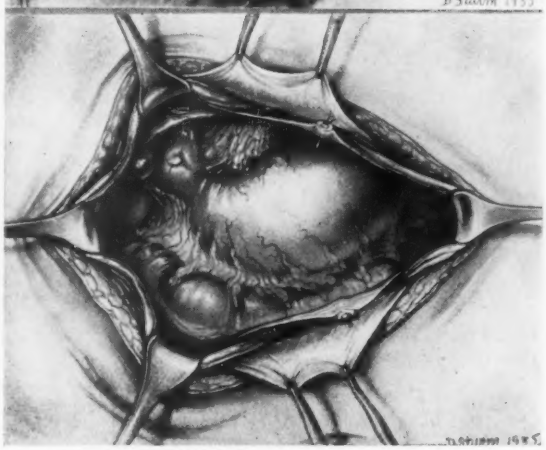

FIG. 9.—Showing stumps of falciform ligament ligated. Wound widely separated by retractors. Liver margin, gallbladder, stomach, duodenum, and transverse colon easily exposed.

the opening in the anterior sheaths. According to their theory, closure of the wall in various planes gives a "muscle lined" wound and prevents a tendency to extrusion of the viscera and postoperative hernia. They say, however, that until the surgeon has had some practice with this type, he will

spend more time working on the abdominal wall than within it, but declare that rapidity of execution comes with experience, and the additional time is well spent.

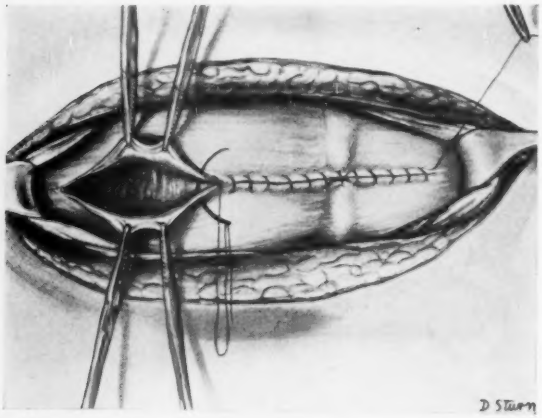

FIG. 10.—Showing closure of peritoneum and posterior sheaths from left to right, without tension. Muscles still retracted.

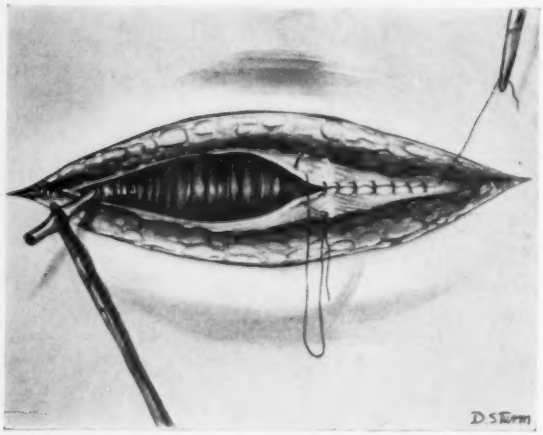

FIG. 11.—Showing recti replaced and anterior sheaths being sutured. Drain tube lateral to right rectus.

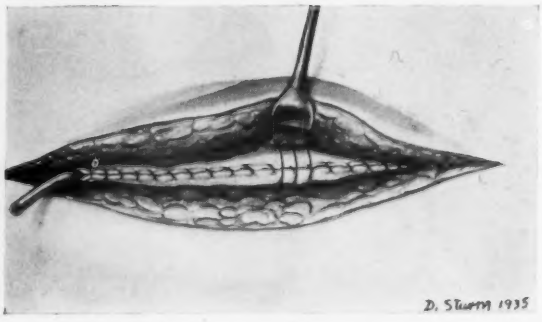

FIG. 12.—Showing fascial suture complete. Three interrupted chromic catgut sutures through linea alba.

C. U. Collins, in 1907, seems to have been the originator of a technic which was described again, in principle, by Souther in 1911, McArthur in 1912, and Schwyzer in 1934. These surgeons have advocated a vertical opening through the superficial structures and anterior sheath of the rectus

muscle on the right side. The muscles are then retracted and the posterior sheath and peritoneum opened transversely. If additional room is needed, the linea alba is divided.

It seems that the principal point upon which there is a divergence of thought is the advisability of severing the recti. Farr,[6] Quain, Moore,[17] and Southam[28] cut them across without so much as a preliminary suture, believing that, since they retract only in segments, an adequate repair may be made by closure of the anterior aponeuroses. Moschcowitz and Jones and McClure[7] suture the muscles to the anterior sheaths on opening, not merely to prevent retraction and exact end to end closure, but chiefly to insure hemostasis. Sloan says the recti have an important function and should not be severed. A number of us agree with him. Others contend that retraction of the muscles sufficiently wide to afford an ample operative field may cause hemorrhage, damage to the nerve supply, and rupture of the muscle fibers to such an extent as to endanger the integrity of the wall. It is clear, therefore, that the different experiences of each surgeon are responsible for the number and variety of transverse incisions devised during the past few decades.

It should not be forgotten that the majority of these incisions may be extended in one direction or another in an approach to the kidneys, spleen, and even the appendix. In my own work, however, when a cholecystectomy and appendectomy are to be done at the same time, unless the appendix is lying very high, I prefer removing it through a separate incision, usually the McBurney.

My interest in the transverse incision in the upper abdomen was stimu-

TABLE I

OPERATIVE PROCEDURES PERFORMED THROUGH A TRANSVERSE INCISION

Stomach.—Pyloroplasty	6
Gastro-enterostomy	7
Gastrectomy (partial)	1
Biliary Tract.—Cholecystectomy	35
Cholecystectomy and appendectomy*	7
Choledochotomy	5
Cholecystogastrostomy	3
Miscellaneous.—Splenectomy	1
Abdominal exploration	7
Drainage liver abscess	1
Liberation intestinal adhesions	1
Duodenal ulcer, perforated	2
Nephrectomy, for sarcoma kidney (left rectus divided)	1
Total	77

* The appendix was removed through a separate McBurney incision in 11 cases.

One transverse incision required secondary closure on account of extensive infection.

lated largely by the difficulties encountered in using a vertical one. I was disappointed in the high percentage of ventral herniae and weakened abdominal walls which followed. Disabling and distressing adhesions, to the parietal peritoneum throughout the entire length of the vertical incision, were observed far too often to be of passing interest. Postoperative pain was not a negligible matter. With these considerations in mind, my first operation through a transverse incision was done in March, 1934.

Since that time, 77 supra-umbilical transverse incisions have been made (Table I). In the beginning, Sloan's technic was employed exclusively. Soon it was discovered that this method required too much surgery, particularly in closing the wound, when there were two parallel openings in the fascia. The Singleton type was then tried, with better success. In Singleton's procedure, however, the surgery was almost as extensive and, in addition, the large space between the sheaths and fat became, in a number of cases, a depository for serum. The technic was a little difficult to master, and our first dozen or more cases were not done well. On this account, we were rather discouraged over the prospect of adopting the incision for general use. About one year ago we tried a modification of the former incisions, as described in the accompanying illustrations. So far as I am able to learn from a careful review of the literature, this technic has not been presented heretofore.

Operative Technic.—For cosmetic effect, the skin incision is made equidistant on each side of the midline. To be adequate, it should extend practically from one costal margin to the other. The opening in the subcutaneous structures, however, should be farther to the right than to the left of the midline for operations on the biliary tract. The exact site of the incision will be determined largely by the width of the costal angle: the wider the angle, the higher above the umbilicus should the incision be placed. In the average patient, the juncture of the middle and lower thirds of the distance between the xiphoid and umbilicus and between two of the linea transversae is the most effective location.

The opening is carried down to the anterior sheaths of the rectus muscles. No dissection is made longitudinally, as simple retraction of the wound is all that is necessary for exposure of the sheaths.

The anterior sheaths are then divided in line with their fibers. Here, the technic is most tedious and difficult. Since the recti are densely adherent anteriorly to the sheaths, especially at the linea transversae, one must elevate the sheaths carefully and, with scissors, dissect the muscles free for a distance of two or three inches up and down. Occasionally, hemorrhage is a little troublesome. Extreme caution must be exercised in liberating the sheaths from the linea transversae, otherwise the muscles may be weakened and their fibers more easily torn by retraction. On the posterior side of the muscles the sheaths can be freed without difficulty, as they adhere only slightly.

Both recti are now retracted laterally and the opening is continued transversely through the posterior sheaths and peritoneum. The falciform liga-

ment is divided between clamps, the ends ligated and dropped back. With adequate retractors, the wound is opened wide for exploration or operative procedure.

Drainage tubes may be brought out through the right angle of the wound lateral to the rectus muscle. This affords a more direct and even more dependent drainage than is obtainable through the vertical incision.

The wound may now be closed in layers, as any other type of abdominal incision. Suturing is more readily accomplished if begun on the left. Since the peritoneum and posterior sheaths are so adherent, they may be closed

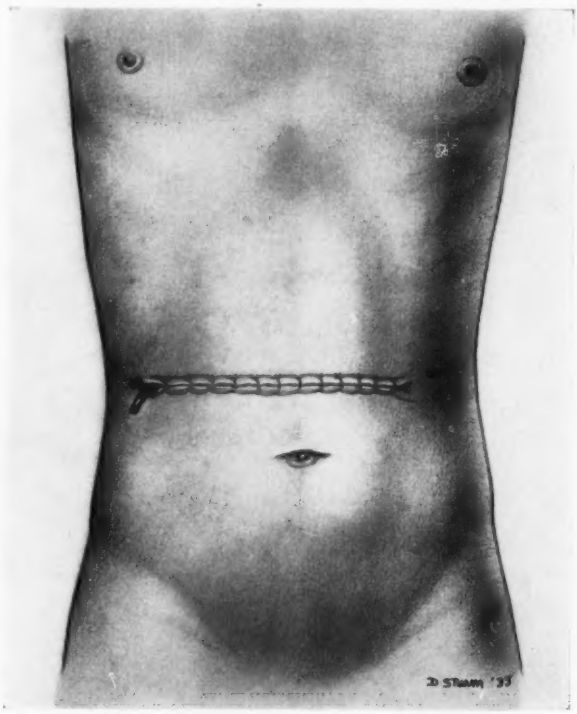

FIG. 13.—Showing operation complete. Skin closed with interrupted suture. Drain through right angle.

together. The divided ends of the falciform ligament may be approximated by including them in the suture. Even though the patient is straining, there is no tension on the wound and its edges may be drawn together with ease. The rectus muscles are then brought to their normal position and the anterior sheaths closed in a similar manner. When the operation is complete, three interrupted sutures of chromic catgut are placed in the linea alba as an additional measure of safety. Retention sutures are unnecessary, but may be used if desired.

In the average case, exposure is ample, and the gallbladder and ducts are easily accessible through this incision. If the operation is to be a high stomach resection, an extension may be made to the left to equal that to the right.

If the appendix is to be removed and the cecum is fairly mobile, this same opening will usually suffice. In many cases, however, an additional McBurney incision may be required for appendectomy.

Schwyzer has called attention to the fact that the gallbladder may be removed through the transverse incision without severing the linea alba or extending the opening to the left side. We have been able to do this in two instances.

In the last 50 cases the foregoing method has been satisfactory in every particular. By eliminating the wide dissection of the superficial structures, we have no dead space for the accumulation of serum or blood. Patients have suffered appreciably less postoperative pain and less distention and distress, and healing has been more rapid. In two of our early cases the linea alba separated, resulting in a moderate bulge and some weakening of the wall. In both these there was extensive suppuration, which was secondary to a badly infected gallbladder in one, and a long drainage of the common duct in the other. As both operations were done before we were familiar with the technic, we failed to bring out the drainage tube lateral to the right rectus muscle. From our more recent transverse incisions, in which we have been reinforcing the linea alba with three interrupted sutures, we have not yet had any adverse results.

We have not adopted this incision for all supra-umbilical operations. With further experience, however, and the exercise of patience and careful attention to detail, we believe it can be employed safely and successfully in practically every one. Fortunately, its application is easiest in those patients who need it most. In doing a considerable amount of upper abdominal surgery, one deals with many large, obese men and women beyond middle age, whose abdominal walls are composed chiefly of fat and thinned out, flabby muscles and fascia. The peritoneum and posterior sheaths are especially thin and friable, making closure of that layer difficult and uncertain. The omentum is thick and, in many cases, the peritoneal cavity seems too full of viscera. As these patients generally take the anesthetic poorly, respiratory effort is increased and wound closure is more difficult. From the standpoint of facility in opening and closing, the transverse incision is particularly advantageous in this group of patients.

Disruption of a vertical wound is to be expected in a small number of the cases just described. It occurs all too frequently, and is a serious and formidable complication. Singleton studied 900 cases reported from several hospitals and found a total mortality of 38 per cent from disruption alone. By the use of the transverse principle, one can eliminate almost entirely this dangerous possibility and thus reduce appreciably the mortality from surgery in the upper abdomen.

Although the various types of transverse incisions differ in one or two respects, all have a number of virtues in common. Of the majority of them, we may say that:

(1) They conform to anatomic and physiologic requirements by follow-

ing the course of the wall structures and preserving the nerve and blood supply.

(2) They promote rapid healing of the wound because of the natural tendency of the edges to come together and the lack of strain upon the sutures.

(3) They lessen the danger of trauma to the tissues, since the fibers which run parallel to the line of incision are sutured across.

(4) They preserve the peritoneum intact in closure.

(5) They permit perfect apposition of the wound edges and, except when extensive superficial dissection has been made, prevent dead space for the accumulation of serum.

(6) They prevent shock of the patient on account of the lack of retraction of the wound margins.

(7) They reduce postoperative pain to a minimum.

(8) They shorten the time of hospitalization and hasten the patient's recovery.

(9) They give an excellent cosmetic result.

(10) They afford ample room and freedom of movement, with an excellent view of the operative field.

(11) They obviate the necessity for extensive packing of the abdominal cavity and thus tend to reduce the amount of postoperative adhesions.

(12) They allow more efficient drainage at a dependent site, and without subsequent damage to the integrity of the abdominal wall.

(13) They reduce materially the danger of postoperative hernia.

(14) They lower mortality from upper abdominal surgery by eliminating almost wholly the possibility of wound disruption.

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EXPERIMENTAL STUDIES OF URETERO-INTESTINAL ANASTOMOSIS

A PRELIMINARY REPORT

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THE employment of uretero-intestinal anastomosis in cancer of the bladder, exstrophy of the bladder, irreparable vesicovaginal fistulae and a few cases of intractable chronic interstitial cystitis has become an accepted surgical procedure. It is obvious from the nature of the two structures to be united, that in order to avoid serious complications, technical skill is required in the performance of the operation. Several different technics of ureteral transplantation have been described. The purpose of the experiments set forth in this paper is to observe in animals the results obtained in the application of the different technics.

Inasmuch as a detailed report of each experiment cannot be undertaken within the limits of this paper, the experiments are discussed in groups and subgroups as follows:

Group I: Ureteral transplantation by the aid of catheters, Coffey's[1] second technic (four experiments).

Group II: Ureteral transplantation by means of a transfixion suture, Coffey's third technic[2] (ten experiments).

Subgroup II A: Simultaneous transplantation of both ureters by Coffey's third technic (one experiment).

Group III: Ureteral transplantation in two stages, a method described by Ferguson[3] (17 experiments).

Group IV: Ureteral transplantation by a combination of Ferguson's first stage and Coffey's transfixion suture, a method developed and perfected by Higgins[4] (four experiments).

Group V: A two stage method of ureteral transplantation in which Ferguson's first stage operation is followed by Coffey's[5] (six experiments).

Group VI: A two stage operation. In the first stage a portion of the ureter overlooped with a silver wire is placed within the lumen of the sigmoid. The anastomosis is completed through the rectum at a later date by dividing the ureters with cutting current (two experiments).

Group VII: A two stage method. With the aid of a linen thread looped over the ureter at the first operation, at the second stage, which is performed through the rectum, the intestinal mucosa is incised longitudinally and the ureter transversely with the cutting current (two experiments).

Subgroup VII A: The technic employed in Group VII is modified by the substitution of silver wire for linen thread (eight experiments).

Subgroup VII B: An addition is here made to the technic of Group VII A by strangulating a triangular area of the intestinal mucosa covering the ureters and the wire loop, by means of three linen sutures (one experiment).

Group VIII: A two stage operation. As the ureters are embedded in the bowel wall, they are wrapped together in a cuff of tin foil, cellophane, or oiled silk one-half inch wide around which is looped a silver wire. At a later date the operation is completed through the rectum by means of the cutting current (six experiments).

Group IX: A two stage method. As the ureters are implanted in the rectal wall, they are inclosed together in a cuff of sheet tin one-half inch wide. The anastomosis is later completed through the rectum by incising the mucosa of the bowel longitudinally and the ureters transversely at the caudal end of the cuff which allows its removal (three experiments).

EXPERIMENTS

Group I: Bilateral ureteral transplantation was performed on four dogs (3, 4, 5 and 6) employing the catheter method described by Coffey as Technic No. 2. Death from peritonitis resulted in each dog within a week. Moreover, it was impossible to keep the catheters in place and functioning. The method was, therefore, abandoned.

Group II: In ten dogs (1, 2, 7, 8, 9, 10, 11, 12, 13 and 14) the ureters were transplanted individually by the transfixion suture method of Coffey described as his third technic. Dog No. 7 lived six months after the second transplantation. Postmortem revealed a normal urinary tract above the anastomosis. Dog No. 8 died suddenly 38 days after one ureter, the left, had been transplanted. Autopsy revealed a normal left kidney, but there was a moderate dilatation of the left ureter. Dog No. 11 survived the second transplantation 105 days. At autopsy it was found that the left kidney, 150 days after transplantation, was a large tense hydronephrotic sac, whereas the right kidney, 105 days after transplantation, was normal. In these three cases, linen was used for the transfixion suture.

In seven other animals catgut was used in two, silver wire in two, and linen in three for the transfixion suture. Three of these dogs after the first transplantation died of peritonitis, living an average of five days. Four died after the second transplantation, surviving an average of four days. In one dog the wire transfixion suture was tightened by twisting it within the rectum. The use of wire as a transfixion suture was thereafter abandoned because in tightening it the tissues were usually torn. Except 7, 8 and 11, all dogs of this group that survived the operation long enough developed obstruction at the site of anastomosis. In one animal the anastomotic fistula had completely closed after 150 days.

Subgroup II A: In one animal (15) both ureters were transplanted at the same operation according to Coffey's third technic. The dog lived two days and died of peritonitis. At autopsy it was found that both kidneys were swollen and congested. There was obstruction at the anastomosis.

Group III: Seventeen dogs (19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 31, 32, 33, 34, 35, 37 and 42) were operated upon by a method derived from Ferguson.[3] The first operation consisted of embedding the ureters in the bowel wall between the muscularis and mucosa for one and one-half inches without interrupting their course to the bladder. In four animals (19, 20, 21 and 22) both ureters were embedded together in a single longitudinal incision, one and one-half inches long, on the anterior aspect of the bowel wall. In ten instances, to prevent angulation of the ureters, a T-shaped incision was employed (23, 24, 25, 26, 29, 31, 32, 33, 34 and 35) so that each ureter entered the bowel wall at its mesenteric border and, running a diagonal course, emerged together

with its fellow in the midline opposite the mesentery. In three instances (28, 37 and 42), two separate incisions at different levels on the bowel wall were employed to implant the respective ureters. Table I illustrates the immediate mortality and the effect of this operation on the nonprotein nitrogen of the blood at given intervals in 21 dogs.

Only two died, one (42) of rabies within ten days, the other of peritonitis six days after the operation. In the latter dog the sigmoid was so distended with hard fecal masses at the time of operation that it was impossible to properly close the muscle layer and serosa over the ureter. In spite of the low mortality of this operation, we observed that immediately postoperative there was a rise in the nonprotein nitrogen of the blood. This

TABLE I

IMMEDIATE MORTALITY AND POSTOPERATIVE NONPROTEIN NITROGEN RETENTION IN 21 DOGS

Dog No.	Days After First Stage	Mg. of N.P.N.
1	60	40
2	57	36.1
3	59	30
4	60	22.2
5	59	25.5
6	60	32.4
7 (Died of peritonitis six days after first stage)		
8	61	38.7
9	105	33.3
10	96	30.7
11	100	36.3
12	70	33.3
13	49	33.3
14	52	36.3
15	50	37.5
16	50	35.2
17	26	37.5
18	41	33.3
19	42	26
20	45	25.5
21 (Died of rabies)		

is due to swelling and hemorrhage into the intestinal wall around the embedded ureters, and to denervation of the ureters which we believe must necessarily accompany their mobilization. Ferguson[3] recommended catheter drainage to prevent ureteral obstruction. The obstruction as evidenced by elevated nonprotein nitrogen spontaneously disappeared within the first 10 to 15 days postoperative. In Chart I the line A represents the level of nonprotein nitrogen of the blood following simple mobilization of both ureters. In the same figure, line C represents the curve of the nonprotein nitrogen of the blood when the operation is completed by embedding the ureters within the wall of the sigmoid.

From these figures it is found that in the average dog, two months after this operation, the nonprotein nitrogen level was 33.3 mg. (The average level of nonprotein nitrogen in a series of ten dogs before operation had been done was exactly 33.3 mg.)

Fifteen of these dogs (19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 31, 33, 34, 35 and 37) were subjected to a second stage operation which was similar to the technic described by Ferguson. The abdomen was reopened and the field of anastomosis exposed. The ureters were divided one inch below their exit from the bowel wall. A small wire, insulated except near the tip, was introduced into the ureters and passed into the lower third of their intramural portion. The insulated handle of the wire was then elevated

so that its long axis became perpendicular to the intestinal mucosa. In this position the high frequency current was applied and the wire passed through the wall of the ureter and underlying intestinal mucous membrane into the lumen of the bowel. The current was then changed to a coagulating current and allowed to remain on while the instrument was withdrawn through the stump of the ureter. The ureteral ends were then ligated with silk. After using the wire in six (19, 20, 21, 22, 25 and 34) animals it was discarded for an insulated wire loop which was employed in nine (23, 24, 26, 28, 29, 31, 33, 35 and 37) instances. The ureteral ends were ligated with catgut and buried within the bowel wall.

Results.—One dog (26) survived the second stage operation for seven months and 19 days. Autopsy revealed a large infected left hydronephrosis and a very large left ureter, almost completely obstructed at the site of anastomosis. The right kidney and ureter were normal. One dog (29) died 44 days after operation. At autopsy the left ureter was completely occluded at the site of anastomosis, where a scar marked the site of the closed fistula. Bilateral hydronephrosis was present. In both dogs (26 and 29) the communication between ureter and intestine had been cut by a wire loop.

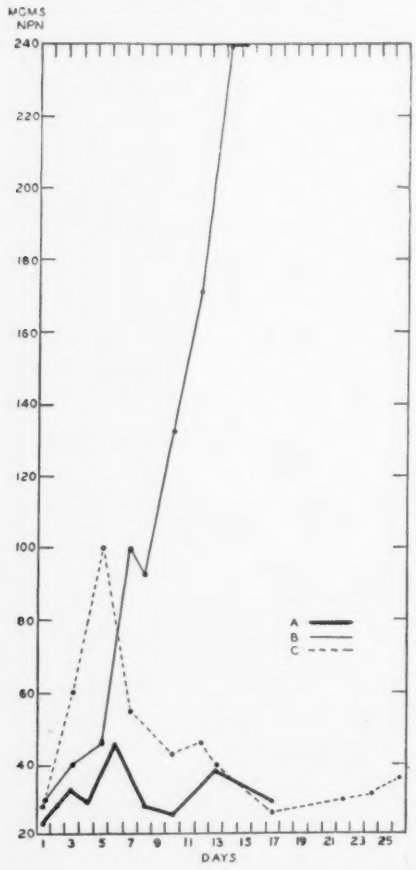

CHART I.

The average life of the 13 remaining animals was ten days. At autopsy a large perirectal abscess was found in five and generalized peritonitis in three. In 11 dogs obstruction was demonstrated at the anastomosis.

Group IV: In four experiments (16, 17, 18 and 27) Ferguson's first stage operation was combined with Coffey's transfixion suture method. The ureters were embedded in the intestinal wall and at the same time they, with the intestinal mucosa, were transfixed by a linen suture at a point near the ureteral exit from the bowel wall. Care was taken not to interrupt ureteral continuity.

Results.—One dog (16) lived 11 days. At autopsy the cause of death was undetermined. Both kidneys were grossly normal. The left ureter drained freely into the bowel, whereas the right ureter drained with equal freedom into the bladder. The remaining three dogs died of acute peritonitis within the first 72 hours. In these three the transfixion sutures were still present, having cut through the intestinal mucosa but not the ureteral wall. Urine was found within the peritoneal cavity of two. In all hydronephrosis and hydro-ureter were already present. In one dog it appeared that the transfixion sutures, which had been put through the ureter transversely, partially occluded the lumen of the ureter. In the last experiment, therefore, the ureters were transfixed in their longitudinal direction rather than crosswise.

Group V: In six dogs (36, 38, 39, 40, 43 and 44) Ferguson's first stage operation was followed after an elapsed average time of four weeks by the following technic.

The ureters were divided one inch below their exit from the bowel wall. Great care was used to dissect the ureteral stumps well back into the wall of the intestine, so that the stab wound into the bowel through which the ureters passed had no muscular tissue intervening between it and the ureter. A stab wound was then made through the bowel wall at a point adjacent to the ureter as it emerged. The ends of the ureters were then passed through these wounds into the lumen of the bowel and the muscle and serosa closed over and around them. (It is surprising to observe how much the ureter retracts after its division. When the stumps have been cut an inch long, after retraction barely sufficient lengths remain for proper invagination.)

Results.—One of these dogs (39) lived nearly two years, and died of causes other than renal failure. One dog (36) died of pneumonia on the ninth day; the urinary tract was normal. Two dogs died of renal infection (43) on the twelfth and (44) on twenty-third postoperative days, and in each case there was unilateral partial ureteral obstruction. In dog No. 44 obstruction was due to a plug of mucus or exudate rather than stricture. This was determined by injecting water into the ureter above the anastomosis and observing its flow into the bowel. No water came through the anastomosis until considerable pressure had been built up within the ureter. Suddenly a small plug of exudate was expelled through the anastomosis, followed by a continuous free flow of the water through the anastomosis. In dog No. 43 obstruction resulted from acute angulation of the ureter at its point of entrance into the lumen of the bowel. Finally, one of these dogs (43) had a mild inflammatory lesion in the kidney which was not due to obstruction. The remaining two dogs (38 and 40) died of peritonitis within 72 hours following the second operation.

Group VI: An additional technic was employed in two dogs (41 and 45). In these, the ureters were embedded in the wall of the bowel in the usual manner except that in the lower third of the intestinal incision the mucous membrane was incised for a distance of one-half inch. Strands of silver wire, size 27, were looped over the ureters and passed through these incisions into the lumen of the bowel. The mucosa was then closed over the ureters and their encircling wire, so that for a short distance they were actually within the lumen of the intestine. Had these wounds healed, we planned to complete the operation through the rectum by dividing the ureters with the high frequency current. Both dogs, however, died of peritonitis within the first 72 hours.

From the foregoing 44 experiments we have concluded:

(1) Animals rarely tolerate a method of uretero-intestinal anastomosis which requires that both the bowel and ureter be opened at the same operation within the peritoneal cavity.

(2) The first stage of Ferguson's operation immediately produces partial blocking of the ureter, due to swelling, induration, and hemorrhage in the bowel wall which surrounds the ureters and, in a lesser measure, to ureteral denervation. The obstruction is manifested by diminution in the output of urine and an increase in nonprotein nitrogren of the blood which, in the average case, reaches a maximum of 100 mg. on the fifth postoperative day. The obstruction has always been spontaneously relieved, usually by the fifteenth postoperative day, and has occasioned no demonstrable permanent renal changes.

(3) Destructive renal changes often become apparent at remote intervals following bilateral ureteral transplantation. In the great majority of cases, if Coffey's principle of transplantation has been employed, lesions in the kidneys are due to stricture or obstruction at the point of anastomosis rather than to an ascending infection through the anastomosis.

This suggests the desirability of maintaining the patency of the ureter by mechanical dilatation during the healing process and, possibly, at intervals thereafter.

(4) The creation of a fistula between the ureter and the bowel by a transfixion suture, Coffey's third technic, has been unsuccessful in the majority of our experiments. It has been of value in decreasing the immediate mortality due to infection, but the transfixion suture has been inefficient in cutting through promptly and completely leading to an inadequate fistula. Two reasons may be advanced for its inefficiency, assuming of course that it were properly placed: first, the knot may slip so that sufficient pressure to cause a slough is not maintained; second, it is entirely possible that when two structures of different texture are included within the same ligature, the most easily strangulated cuts through first, loosening the tension on the other so that it is able to remain intact.

(5) The second stage of Ferguson's operation also proved unsuccessful in our hands. It has the same objections as Coffey's transfixion suture. In the great majority of our cases we were unable to complete an amastomosis which remained competent. Furthermore, there occurred a high incidence of associated localized infections.

(6) Ureteral obstruction due to stricture at the site of uretero-intestinal anastomosis more frequently follows side-to-side anastomosis. Permanent patency of the anastomosis is best attained by bringing the end of the ureter into the lumen of the bowel, an end-to-side anastomosis. Because of the retractility of the ureter when severed, an excess of the ureter should be brought within the lumen of the intestine, so that its end will not retract into the bowel wall, producing subsequent obstruction. Retraction may account for some of the undesirable late results following Coffey's first technic.

(7) During the period of ureteral obstruction when little or no urine is passing through the anastomosis mucus, fibrin or blood may accumulate within the lumen of the ureter and produce obstruction.

(8) Very frequently infections within the abdominal wound may delay secondary laparotomy.

(9) At the second stage operation the site of uretero-intestinal anastomosis is frequently firmly adherent to the surrounding structures. The field of operation is, therefore, difficult to expose. Many adhesions must be separated and hemostasis may be difficult.

It is apparent that there are many advantages in allowing the ureters to become firmly healed within the wall of the bowel before a communication is established between them. These advantages we believe are largely annulled if the anastomosis is completed by a secondary abdominal operation.

Following the first stage transplantation of ureters the intramural parts of the ureters are separated from the lumen of the bowel by only a thin layer of mucous membrane. Because of this relationship the rectum offers a satisfactory avenue through which to approach the second stage operation. On the other hand it adds other problems, the chief being the restricted area in which the

operation must be conducted. We have, therefore, sought to modify Ferguson's first stage operation in some manner, which, without increasing its risk would enable us to complete the anastomosis by the intrarectal approach.

To this end the following experiments have been carried out.

EXPERIMENTS

Group VII: At the first stage operation a linen thread with needles on either end was looped over the ureter in the lower third of its intramural course by passing a needle on each side of the ureter through the mucosa into the lumen of the intestine. These needles were caught with forceps through a proctoscope and pulled through the anus. This portion of the ureter was then buried in a fold of mucous membrane by three mattress sutures of linen. The muscle and serosa were next closed over all. The ends of the thread were fastened together well within the rectum and the excess thread cut off to prevent the dog from interfering with it. Two dogs (46 and 47) were operated upon in this manner, only the right ureters being implanted. The anastomosis was to have been completed later by dividing the ureter from within the rectum with the high frequency current using the linen thread as a guide. In the first dog (46) after 19 days the thread had disappeared. This dog died 27 days later, and autopsy revealed that death was due to peritonitis. In the second dog (47) ten days after the first stage operation we were able to locate the thread through the proctoscope but during our manipulations the thread was accidentally broken and pulled out. The linen had apparently been disintegrated by the intestinal fluids and was not employed thereafter.

Subgroup VII A: In eight dogs (48, 49, 50, 52, 53, 54, 55 and 57) both ureters were implanted simultaneously without interrupting their course to the bladder, and in addition silver wire, size 27, was looped over them instead of linen thread. In three dogs (48, 49 and 50) the ureters were embedded in separate incisions, necessitating the use of two wires.

In the first dog (48) the wires had disappeared at the end of 14 days. When the second stage was attempted the animal was apparently in good health. The second dog (49) was found dead in his cage on the morning of the fifth postoperative day. The abdominal wound had disrupted. The third dog (50) died under the anesthetic. In the remaining five animals (52, 53, 54, 55 and 57) the operation was simplified by embedding both ureters in a single incision and using one wire loop to include both ureters. In the first dog (52) the wire was cut out with difficulty at the end of ten days. Fourteen days later he died in uremia with a nonprotein nitrogen of 120 mg. Bilateral hydronephosis was found at autopsy. In the next case (53) the second stage was again performed with considerable difficulty, three weeks after the first operation. Four days postoperatively the dog died of renal failure. At autopsy there was an advanced hydronephrosis of both kidneys and both ureters were enormously dilated. The cause of obstruction was difficult of explanation since both anastomoses emitted water freely and without undue pressure when injected above their union with the bowel.

At this time it was discovered that the two limbs of the wire loop, each about four inches long, were not insulated. The current was therefore leaking. This was corrected.

Dog No. 54 gradually lost weight and strength following the first stage operation and died on the fourteenth postoperative day before the second stage operation was attempted. Postmortem examination revealed a large fecal impaction accumulated on the coiled ends of the wire loop. The ureters were definitely obstructed by the wire loop. After the wire was removed the obstruction was relieved. Dog No. 55 died about one hour after the first stage operation. He did not react from the anesthetic. The fifth dog did well immediately after the first stage. Seven weeks later, however, when the second stage was attempted, it was discovered that the wires were not in place. Roentgenograms substantiated their absence. At this time it was not clear why we so often found hydronephrosis and hydro-ureter after the second stage when no obstruction could

be demonstrated in the anastomosis at autopsy. We were inclined to believe, however, that in some way the second stage was at fault. On this hypothesis we attempted to improve the second stage by bringing an excess of the ureteral stump into the lumen of the bowel as is done in Coffey's first technic. The above method therefore was further modified in an effort to accomplish this purpose.

Subgroup VII B: Three sutures of linen were passed through the mucous membrane and out again at a distance of about one-third inch. These three sutures formed a triangle with its apex above and its base below. Within the area of this triangle the two limbs of the wire loop over the ureters were passed into the rectum. When the three sutures were tied the blood supply was completely cut off to the mucosa within their confines. After sloughing occurred, the ureters, with the wire looped over them, for about one-third inch, were exposed within the lumen of the bowel. This experiment was performed on one dog, No. 56.

Dog 56 died on the sixth postoperative day. Autopsy revealed that the strangulated mucous membrane had sloughed. The portions of the ureters which had become exposed by this slough were necrotic and the muscularis and serosa had failed to heal over this area. The result was a localized abscess from perforation of the bowel. It is of the utmost importance, therefore, to preserve the mucous membrane of the bowel as a protection against infection while the ureters are healing within the intestinal wound.

Group VIII: In order to meet this situation the first stage was again modified. The ureters were embedded in bowel wall, using a T-shaped incision, and in addition they were surrounded by a cuff of tin foil one-half inch wide. The wire loop was so placed that it embraced the ureters over this cuff. The purpose of this cuff was to prevent the ureters from becoming adherent to the bowel wall in the lower third of their intramural portion. At the second operation we proposed to incise the mucous membrane in a longitudinal direction between the limbs of the wire loop for the distance of one-half inch. Then by making traction on the loop we could bring the tin foil into view through this incision. The ureters were to be severed at the lower end of the cuff so that the loop and the cuff, together with the ends of the ureter, would be pulled into the lumen of the intestine. In this manner it was hoped that we would secure the same end result accomplished by Coffey's first operation. Six dogs (59, 60, 61, 62, 63 and 64) were operated upon in this manner. In three (59, 60 and 64) tin foil was used to enclose the ureter. No. 59 lost weight after the first stage. A week later when the nonprotein nitrogen of the blood had risen to 63.1 mg., the second stage was performed. The animal survived the second stage 18 weeks and died because of ureteral obstruction. Dog No. 60 died of pneumonia four days after the first operation. In dog No. 64 the nonprotein nitrogen of the blood was 100 mg. on the fourteenth postoperative day. The second stage was then attempted but it was found that stricture of the bowel had occurred at the point of anastomosis. The second stage could not, therefore, be carried out. This was the first time that we had encountered a definite stricture of the intestine following the use of a T-shaped incision in the muscularis. In four instances there had been some narrowing of the bowel wall at the anastomosis, which was detectable in passing a large sized proctoscope. However, the proctoscope had always passed through anastomotic section of the bowel with little difficulty. On the nineteenth postoperative day the dog died. Autopsy revealed a pronounced stricture of the bowel. Above this stricture the intestine was dilated to four times its size and filled with fecal material, whereas below this stricture the rectum was empty and collapsed. There was, in addition, bilateral ureteral obstruction which had resulted in hydro-ureter and hydronephrosis.

In dog No. 61 cellophane was used as a cuff instead of tin foil. The first stage was well tolerated and two weeks later the second stage was attempted but, unfortunately, during our manipulation a limb of the wire loop caught in the window of the proctoscope and was pulled out. About four weeks later the dog was in good health with the nonprotein nitrogen of the blood at 50 mg.

In the last two experiments (62 and 63) oiled silk was substituted for cellophane.

The latter material was found to be much easier to handle. Dog No. 62 died of pneumonia 12 days after the first stage. Autopsy revealed normal kidneys and only slight dilatation of the ureters. There was, however, a moderate degree of constriction of the bowel at the point of the anastomosis. Dog No. 63 lost weight after the first stage. On the fourteenth postoperative day the second stage was successfully performed through the proctoscope by incising the intestinal mucosa longitudinally between the limbs of the wire loop with the cutting current. The incision was begun about one-third inch beyond the loop and brought forward. While traction was being made on the loop the electrode came in too close proximity to one of its limbs, causing the loop quite unexpectedly to cut through both ureters. However, we were able to visualize the field of operation and extract the oiled silk with forceps. In removing the oiled silk the ends of both ureters were delivered into the lumen of the bowel. The result of this second stage, therefore, was in a mechanical sense the ideal for which we had worked. We were surprised to learn that this dog's blood drawn at the time of the operation contained 240 mg. of nonprotein nitrogen per 100 cc. of blood. The dog survived the second stage five days and postmortem revealed bilateral pyelonephritis which had already destroyed most of the kidney substance. There was no dilatation of the pelvis of either kidney or of either ureter. No obstruction in the anastomosis could be demonstrated.

Postmortem examination of the intestinal mucous membrane at the point where the wire loop had cut out revealed a small elliptical ulcer about one-half by one-third inch, its long axis being parallel with the course of the ureters. Apparently the retractile power of the ureters when they were severed had helped to pull apart the cut edges of the mucosa. The base of the ulcer was formed by the muscle layer of the bowel. It had healed perfectly and its integrity had not been interfered with by the cutting current at the time of the second operation. The cut ends of the proximal segments of the ureters could be seen in the upper margin of the ulcer. Both emitted water freely within the lumen of the bowel when it was injected into the ureters above the anastomosis.

We were convinced by these experiments that when a wire is looped over the ureters the degree and the duration of obstruction which follows Ferguson's first page operation is both increased and prolonged (Chart I, Curve B), due largely to the accumulation of fecal matter against the coiled ends of the wire, which in the course of a few days usually amounts to a large fecal impaction. Both the weight of the mass and the constant peristaltic effort to expel it caused a constant traction on the ureters. Accordingly, we decided to attempt the operation without the use of wire and employed the following technic.

Group IX: Both ureters were embedded as low as possible in the wall of the rectum and in the lower one-third of their intramural course they were surrounded by a cuff of sheet tin one-half inch wide. This tin was thin enough to be pliable and was also highly magnetic. After healing had taken place we intended to complete the anastomosis by excising the cuff with the aid of a large glass proctoscope with an elongated window on the side. The chief difficulty in such an operation was to locate the cuff at the time of the second stage operation. We anticipated some aid in the use of a magnet if we were unable to locate this body by other means.

EXPERIMENTS

This operation was performed on three dogs (65, 67 and 69). No. 65 gradually lost weight and strength after the first operation and died on the eighteenth postoperative day. The nonprotein nitrogen of the blood had rapidly risen during these 18 days until it had reached 300 mg. per 100 cc. of blood. At postmortem both kidneys were extensively infected. No evidence of dilatation of either ureter was present. The chief finding of interest, however, was that the metal cuff had slipped in the bowel wall and

had come to lie at the upper end of the intestinal incision where the ureters entered the rectal wall, rather than at the lower angle where we had placed it. In that position it must have almost completely blocked both ureters as a result of acute angulation.

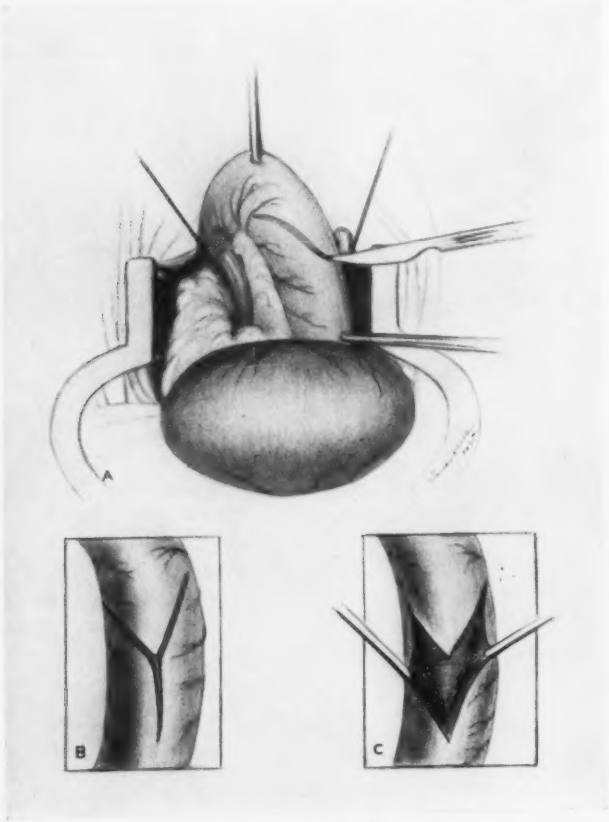

FIG. 1.—A, B, C.

Accordingly, in the other two dogs (67 and 69) we employed a Y-shaped incision (Fig. 1, A and B), placing the metal cuff in the stem of the Y. The V-shaped area of muscularis between the two arms of the Y was not separated from the underlying mucosa (Fig. 1, C) and the cuff could not slip upward beyond its apex when the wound was closed (Fig. 1, D). No. 67 lost weight after this operation and on the fourteenth postoperative day when the second stage was done, the nonprotein nitrogen in the blood was 240 mg. The metal cuff could be felt with the tip of the index finger. We could detect the impact of the metal against the glass proctoscope. The site of the cuff could also be determined by the presence of petechiae in the mucosa covering it. The bowel was found to be slightly constricted at the level of anastomosis. The metal was successfully removed and at the end of the operation the ends of the ureters hung freely

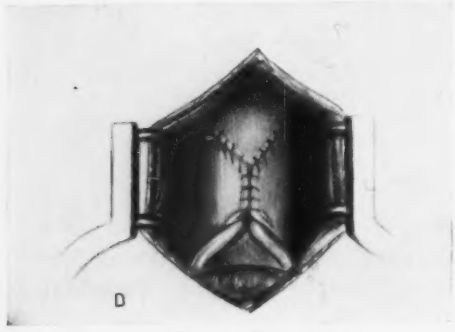

FIG. 1.—D.

in the lumen of the bowel. Five days later the dog died. Postmortem revealed hydronephrosis and hydro-ureter on both sides. The ureters were unobstructed and draining freely into the bowel. Clearly this dog's death was due to the ureteral obstruction which had preceded the second stage. Dog No. 69 did well after the first stage. The nonprotein nitrogen in the blood had risen on the third postoperative day to 80 mg., but by the sixth day it had dropped to 36 mg. On the following day we attempted to remove the metal. It could be felt both through the proctoscope and with the index finger. There was, however, no visible indication of its position and because of this fact we failed in the attempt to remove it. In our manipulations the rectal wall was perforated and the dog died four days later of peritonitis.

CONCLUSIONS

We feel that the following conclusions are substantiated by the above experiments:

(1) If a wire is looped over the ureters at a first stage ureteral operation and left coiled within the rectum for a period of two weeks, it will so impair renal function through ureteral obstruction that life usually is not long maintained. In procedures which elevate the nonprotein nitrogen of the blood to 150 mg. per 100 cc. of blood, though the pressure be subsequently relieved, the animal will not usually survive.

(2) The use of a metal cuff, if properly placed, does not interfere with the healing process and is probably no more injurious to renal function than a wire looped over the ureters. Such a cuff produces no demonstrable direct injury to that portion of the ureter which it embraces. Its removal, however, is too difficult to be practical in human subjects.

(3) Ureters are easily divided by the wire loop and their division in this manner results in an end-to-side anastomosis.

(4) Deaths from renal failure which we have reported following division of the ureters with a wire loop cannot be attributed to renal changes which follow the division, but rather must be regarded as destructive processes within the kidney which have preceded the division.

(5) It is probable that the undesirable effects of the first stage operation can be obviated in man provided the ureters can be catheterized through the cystoscope by draining the kidney pelves during the obstructive period with indwelling ureteral catheters; in patients who cannot be ureterocatheterized preoperatively obstruction may be minimized or obviated by allowing the ends of the wire loops to clear the anus instead of coiling them within the rectum. Infection either in the intestinal wall or in the peritoneal cavity has not occurred as a result of using a wire looped around the ureters with its ends transfixing the intestinal mucosa and fastened together within the rectum. The only objection to its use in connection with Ferguson's first stage operation is its tendency to produce ureteral obstruction. We have been unable to prevent obstruction in dogs by the use of indwelling ureteral catheters for two reasons: first, the dog's ureters are very small and will not admit catheters large enough to adequately maintain urinary drainage for a period of ten days or more; secondly, it is practically impossible to keep catheters in place that long. In man, however,

continuous drainage of the renal pelvis by an indwelling ureteral catheter, size No. 7, is practical. Furthermore, in man the ends of the wire loops can and should be allowed to clear the anus. We believe, therefore, that this technic may prove a safer and simpler method of ureteral transplantation.

Quite recently Brenizer[6] has described a two stage method of transplanting the ureters in the bowel. His second stage was performed through the rectum with the aid of wires and an electric current, necessitating, therefore, only one abdominal operation. He performed this operation on a woman with irreparable vesicovaginal fistula. So far as we know, he is the first to utilize this plan of ureteral-intestinal anastomosis in the human.

Coffey's second technic has been criticized adversely because the large ureteral catheters, sizes 10 and 12, appear to have caused pressure necrosis of the ureters in certain instances. This criticism would hardly be applicable to ureteral drainage for a shorter interval with smaller catheters.

SUMMARY

(1) In our experience the accepted methods of ureteral transplantation, when applied to dogs, have nearly always been fatal.

(2) The high mortality of the operation is due to peritonitis or obstruction of the ureters at the point of the anastomosis.

(3) Renal infections developing at more or less remote periods following transplantation are in the majority of cases sequelae of obstruction.

(4) Ureteral obstruction results from angulation of the ureter, stricture of the ureter, or from a plug of exudate within the end of the implanted ureter. A brief period of partial or complete obstruction following operation allows the exudate to collect and become viscid.

(5) In these experiments we observed that anastomoses produced by transfixion suture or by any known modifications of that technic were most prone to develop stenosis. It is possible that in some of these cases at least, an adequate fistula was not made at the time of operation.

(6) End-to-side anastomoses, Coffey's first technic, where the cut end of the ureter is brought well within the lumen of the bowel, are least likely to develop stricture.

(7) If stricture follows an end-to-side anastomosis, it is usually because an excess of ureter within the lumen of the intestine has not been maintained following operation. Peristalsis and elasticity of the ureter operate to bring about this postoperative maladjustment.

(8) Ferguson's first stage operation has an exceedingly low primary mortality and is followed apparently by no permanent impairment of renal function.

(9) In order to benefit in the fullest measure by the advantages of Ferguson's first stage, the anastomosis must be completed at a second operation, carried out through the rectum.

(10) At the second stage the ureters should be completely divided so that the late danger of stenosis may be minimized.

(11) To this end, silver wire was looped over the ureters at the first operation.

(12) When wires were looped over the ureters in dogs and allowed to remain in place from 10 to 14 days, they often obstructed the ureters to such an extent that the animals did not long survive their removal.

(13) The tendency of wire to obstruct the ureters in dogs may be due to the fact that it was necessary to leave the ends of the wire fastened together by a shot well within the anus. This allowed the wires to ensnare the contents of the bowel. In time the weight of the impaction plus the efforts of the bowel to expel it by increased peristalsis produced such traction on the wire loop that the ureters could not function.

(14) In the human, where the cooperation of the patient permits the ends of the wire to clear the anus, the tendency to obstruct may possibly be largely removed.

(15) Nevertheless, if this method of transplantation is employed in man, it is highly desirable where possible to drain both kidney pelves while the wires are in place by indwelling ureteral catheters.

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BILATERAL ASEPTIC NECROSIS OF THE FEMORAL HEAD

PROBLEMS ARISING IN A COMPENSATION CASE

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THE case to be presented represents a very interesting problem from the clinical, pathologico-anatomic aspect and, especially, from the viewpoint of evaluating the amount of disability following an industrial accident.

CASE REPORT

A 45 year old man entered the clinic, complaining of pain and stiffness of the right hip. Two years before admission he slipped on wet ground while carrying one end of a long plank. He was knocked down backwards and was struck over the right hip anteriorly. There was immediate pain around the right hip. He walked with difficulty and his superintendent assigned him a lighter job for the remainder of the day. Roentgenograms were not taken but heat therapy was advised. He improved greatly but the pain did not disappear completely. He returned to work in two weeks. After four or five weeks he had to stop working again because of pain in the hip and limp. He was then in bed four or five months. During the winter months especially pain and stiffness in the hip joint were severe. About six months before admission the hip became almost completely rigid, and since that time he has been unable to put his right shoe on. Pain is less marked now and for the last year weather changes have had very little effect. Patient has lost 20 pounds since the accident.

On physical examination, the patient is a well developed, powerfully built man who walks with a marked right-sided limp. The right lower extremity is held in about 25° external rotation, 15° abduction and 10° flexion; only 10° of flexion is possible. There is slight tenderness over the anterior aspect of the hip. No atrophy of thigh.

Patient was admitted for physiotherapy treatment, under which he improved considerably. The pain disappeared almost completely and there was increase of motion (flexion from 165–120°). Patient was then discharged to continue with heat treatment at home. He returned again after one year. There was no improvement, the hip was practically rigid, in marked flexion—abduction and external rotation contracture.

Roentgenograms were taken at different occasions (the earliest six months after accident); they always showed more or less the same, very unusual picture. The head of the femur appeared, on both sides, containing a very dark shadow which on the left was wedge-shaped, the basis of the wedge comprising almost the entire joint surface, the point in the center of the neck. On the right side the sclerotic area involved the subchondral region, but the other part of the head showed very irregular bony trabeculation. Through the upper part of the head of the femur, opposite the roof of the acetabulum, extended an irregular fracture line more or less parallel to the joint surface, separating a slightly flattened lentil-shaped fragment from the other portion of the femoral head. Where the fracture line ended at the joint surface a small spicule of bone protruded into the joint cavity. Otherwise, the joint cavity was of normal width, the joint surfaces smooth, only in its inferior part beginning formation of marginal exostoses could be seen on the ilium on the right side.

From the clinical and roentgenologic findings the diagnosis of a degenerative (hypertrophic) arthritis of the right hip joint was made, developing most likely upon the basis of an intra-articular fracture of the head of the femur. The dark shadow of the femoral

epiphyses was most unusual for hypertrophic arthritis, but was considered as a very pronounced degree of reactive osteosclerosis in the subchondral zones.

Because there was practically no improvement, despite protracted physical therapy treatment, an exploratory operation, followed possibly by an arthroplasty, seemed indicated.

Operation.—The right hip joint was exposed between tensor fasciae latae and gluteus medius. The joint capsule was considerably thickened. It was incised and the head of the femur was dislocated into the wound. It was markedly misshapen; it was enlarged and showed a cartilaginous cover with very pronounced degenerative changes and unevenness. The ligamentum teres was still present and there were marginal exostoses entirely around the joint surface. Eroded areas of the joint surface were relatively scarce. The head of the femur was trimmed to reduce it in size, and here a very unusual picture was

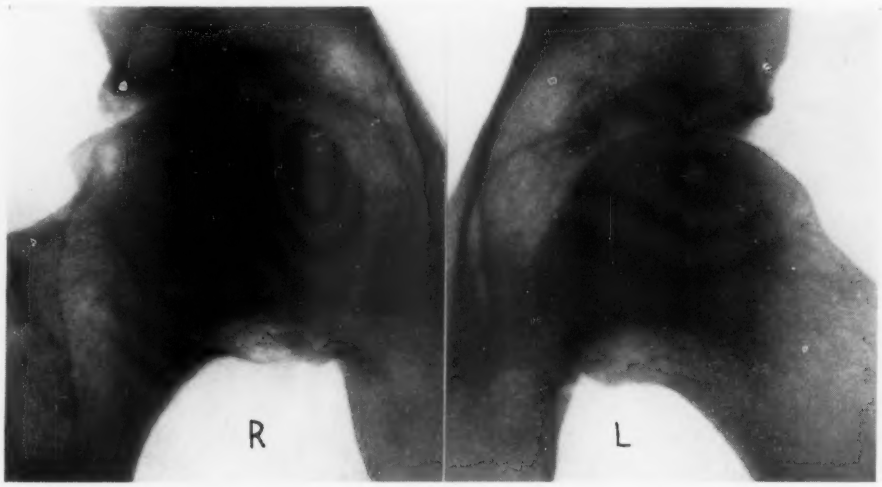

FIG. 1.—Right and left hip joints with dark shadow of epiphysis due to aseptic necrosis. Subchondral fracture line running through upper pole of right femoral head with small spicule of bone, pointing into joint cavity. Resorption of necrotic bone more advanced on the right side. Mild hypertrophic arthritic changes.

encountered. For the greater part, the head of the femur was necrotic. The spongy bone was dense, yellow, and not bleeding. The yellow necrotic areas were surrounded by hyperemic, more porotic portions which were separated from the necrotic bone by a sharp line of demarcation. Almost all of the necrotic bone tissue was removed, together with the joint cartilage. The denuded head was covered with a flap of fascia lata which was also sutured to the joint capsule. The head was reduced and the capsule closed.

The findings at time of operation explained very well the roentgenologic picture. The dark shadow was due to an aseptic necrosis of the epiphysis. Better understanding of the clinical and roentgenologic picture resulted from the histologic examination of the pieces removed from the head.

Pathologic Report.—Received a great number of pieces of the head of the femur; most of them were flat and covered by joint cartilage. Put together, the pieces make up the entire joint surface of the head. The joint cartilage shows marked signs of degeneration and unevenness. It is, however, eroded and replaced by fibrous tissue or fibrous cartilage only in a few places, especially around the insertion of the ligamentum teres. The underlying bone tissue shows essentially two portions: one is very dense, yellow, with occluded marrow spaces; the other is grayish-red, hyperemic, more porotic spongy bone. The demarcation between both portions is usually represented by denser grayish

fibrous tissue. Exostoses have developed at the joint margin, overlapping the old joint cartilage to a considerable degree.

Histologic examination showed the process of reorganization of the aseptic necrosis of the head of the femur in a well advanced stage. In the areas of necrosis the spongy bone is of normal density; it lacks the cellular stain entirely. The marrow spaces are, to the greatest extent, filled by amorphous granular material which contains also a few small fragments of spongy bone. These small fragments came from a fracture space which extends for a considerable length, parallel to the joint surface, through the subchondral bone. The fracture also involves the joint cartilage which shows in several places complete interruption, with overlapping of the cartilaginous fragment ends. Because some of the subchondral bone remained in connection with the joint cartilage, it seems in the roentgenogram as though a spicule of bone was protruding into the joint cavity

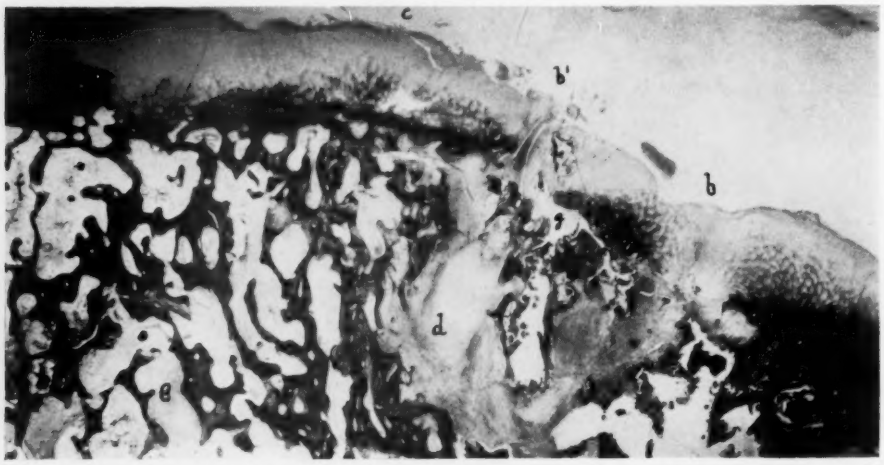

FIG. 2.—Low power photomicrograph through joint surface of the head of the right femur. Area of aseptic necrosis (a) separated from reorganized bone (c) by a zone of fibrous tissue. The reorganization of the bone marrow has led to normal fatty marrow at (f), (b), and (b'). Fracture of joint cartilage with subchondral fracture space (g). Marked degenerative arthritic changes of the joint cartilage at (c) (fibrillation and loss of basophilia).

at the place of overlapping. Along this fracture space which primarily extended through necrotic bone, trabeculae and bone marrow gradually became worn off during weight bearing. Healing cannot take place because of the absence of living tissue. Thus the small fragments first accumulated in the fracture space; here, they became diminished in size and were gradually massaged into the nearby marrow spaces. This led to the dark roentgenographic shadow of the femoral epiphysis.

At the periphery of the area of aseptic necrosis, a zone of reorganization has formed, characterized by loose fibrous bone marrow, relatively rich in vessels and inflammatory cells. Among the latter, lymphocytes are prevalent but plasma cells also are quite frequent. Where the fibrous bone marrow reaches the necrotic fatty marrow, the fatty cells disintegrate. Their fatty content becomes dissolved and may again merge to form larger oil cysts, typically surrounded by large protoplasmatic multinucleated cells of syncytial coherence.

At other places the decomposition of fatty substances leads to irregular calcification. The free fatty acids combine apparently with lime salts of the blood to form calcium salts of fatty acids. In the surroundings of this granular calcification bone apposition takes place also along the surface of the necrotic bony trabeculae. In the first stage this bone formation is very primitive, dark-blue fibrous bone which resembles somewhat the calcification of the necrotic bone marrow. In more mature stages, however, lamellar

bone tissue is found on the surface of the old necrotic bony trabeculae. Considerable but irregular osteosclerosis results thus at the zone of reorganization.

The joint cartilage does not show signs of necrosis. There are, however, many changes of degenerative and hypertrophic arthritis. At the joint margins, but also along the joint surface, the joint cartilage becomes invaded by bone marrow spaces from below. This invasion represents the beginning of a process of enchondral ossification which results in formation of new spongy bone. The zone of provisory calcification is frequently overrun, so that in more advanced stages two layers of calcified cartilage may be found at two different levels: the older one more distant from the joint surface; the more recent one, closer. At the joint margins the process of enchondral ossification leads to typical formation of marginal exostoses. Here, the noncalcified joint cartilage shows proliferation of its cells with gradual transformation of the hyaline ground substance into fibrous cartilage.

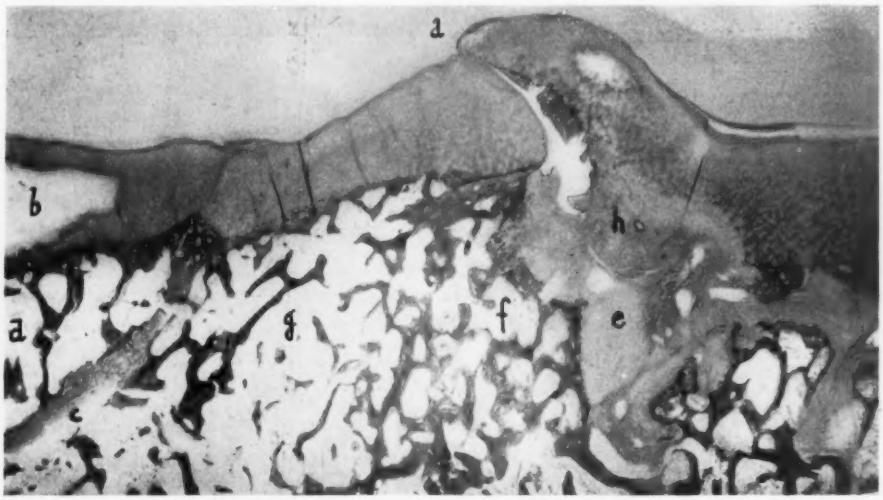

FIG. 3.—Low power photomicrograph through head of right femur. Subchondral fracture line opens at (a) into the joint cavity with overlapping of the fragments of joint cartilage. Fracture space filled with fibrous tissue eroding the joint cartilage from below at (h). Hypertrophic arthritis with formation of exostoses (d) over the calcified layer of old joint cartilage (c). (b) Artificial defect in joint cartilage. (f) Reorganized spongy bone with fibrous bone marrow. Fatty bone marrow at (g).

A fibrous tissue panus may also be seen at the free joint surface, especially at the joint margins and at the site of fracture of the joint cartilage. Here, the fragments have become partially reunited by fibrous tissue which is in part derived from the cartilage itself, from which it had been freed by resorption of the hyaline ground substance.

From these findings we conclude that we have to deal with a case of bilateral aseptic necrosis of the head of the femur. On the right side the process is older and in a more advanced stage of reorganization, but the analogous roentgenogram on the left side proves conclusively that there is the same process present. The patient never complained of the left hip; all his symptoms were centered around the right hip. Bilateral aseptic necrosis of the femoral head is an extremely rare condition in adults. In juveniles it is not so infrequent, in form of a bilateral Perthes' disease. To my knowledge, the only case of a bilateral occurrence (without fracture of the neck of the femur) in an adult was described by me in 1926.[1] The autopsy on a woman, 77 years of age, revealed marked arthritic changes

in both hip joints, resulting from an advanced stage of reorganization of epiphyseal aseptic necrosis. In both femoral heads subchondral fracture lines were present exactly of the same appearance as in our present case. There was no more marked trauma in the history. The question as to etiology had to remain open, the traumatic and embolic factors being in the foreground. The subchondral fracture lines were evidently secondary. They developed gradually, with the resorption of the necrotic bone, and the weakened mechanical resistance of the femoral heads to weight bearing. They represent a typical occurrence in epiphyseal necrosis and are "spontaneous" rather than traumatic fractures (Perthes', Köhler's and Freiberg's disease).

Our present case is a compensation case. The patient claims that his disability started with an industrial accident. A direct trauma to the hip was followed by pain and stiffness. Roentgenograms were not taken until six months after the accident. They showed then, on several occasions, the above mentioned picture. It is quite certain that the trauma suffered by the patient cannot be responsible for the aseptic necrosis of both femoral heads. The patient never complained of the left hip, which shows essentially the same picture as the right. There is only one difference, i.e., in none of the numerous roentgenograms is there present a subchondral fracture line in the left hip. However, it is present in the earliest picture in the right femoral head. The aseptic necrosis evidently preceded clinical symptoms for a long time. It is possible, and this is the only thing which speaks in favor of the patient, that this subchondral fracture of the right femoral head is due to the trauma the patient sustained. The aseptic necrosis, however, evidently in this case without traumatic etiology, preceded the clinical symptoms for a long time. It has to be considered as a spontaneous form of aseptic necrosis which shows that we are still very far from a clear understanding of this peculiar bone pathology. The secondary subchondral fracture is intra-articular and, to a large extent, certainly has led to augmentation of arthritic symptoms; it may even be that the clinical manifestations started with the occurrence of this fracture. On the other hand, it is true that epiphyseal aseptic necrosis *per se* may be followed by quite marked degenerative and hypertrophic arthritic changes, the so called osseous form of arthritis deformans (Axhausen), without occurrence of a more pronounced secondary complicating trauma. Therefore, the patient has to be considered, from the medicolegal point of view, in the same light as a case with metastatic malignancy or with Paget's disease, who sustains a fracture of the affected bone while working. His claim for compensation must be rejected on the basis that his primary bone disease, i.e., the aseptic necrosis, is certainly not due to the industrial accident. The subchondral fracture may be the result of the injury, but since it develops so frequently without it, it must not necessarily be attributed to the trauma. It is to be expected that symptoms similar to those existing on the right side will also develop, sooner or later, on the left side. This will then prove definitely

that the entire pathology in this case is essentially independent of the industrial accident.

We had the occasion recently to observe another, somewhat similar case which on histologic examination proved to be an aseptic necrosis of the femoral head.

Case Report.—A colored man, 31 years of age, complained of pain in the left hip, which came on very gradually. The only thing the patient could offer in explanation was that during his work (butcher) he had to assume a certain position in which his hip tired easily. The hip became stiff but limbered up spontaneously. On physical

FIG. 4.—Aseptic necrosis of the head of the femur in a 31 year old colored man. Irregular osteoporosis by reorganization of the necrotic areas which still appear in normal bony density. Slight narrowing of the joint space.

examination mild flexion contracture with some limitation of motion was found. Laboratory findings were essentially negative except for the roentgenograms which showed an unusual picture of irregular osteoporosis in the femoral head and slight narrowing of the joint space. Physiotherapy treatments followed by immobilization in a plaster case did not afford any relief of symptoms. Biopsy from the head of the femur and the joint capsule was performed, which showed a typical picture of a subchondral aseptic necrosis undergoing reorganization by fibrous bone marrow. There were nonspecific chronic inflammatory changes in the joint capsule, but not more so than could be expected in a case of aseptic bone necrosis.

This case, as in the first one, shows that aseptic necrosis of the femoral head may develop in adults without marked trauma and apparently without any underlying vessel disease. Since we do not know more about the etiology of aseptic bone necrosis, it is to be considered as an idiopathic disease which may lead to considerable functional impairment and its consideration may become of great importance in industrial medicine.

REFERENCE

[1] Freund, Ernst: Zur Frage der aseptischen Knochennekrose. Virchow's Archiv., vol. 261, p. 287, 1926.

THE TREATMENT OF OLD UNREDUCED NASAL FRACTURES

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RECENT fractures of the nose have been exhaustively considered, but the surgical management of old unreduced nasal fractures has been dealt with sparingly. Although this type of fracture is classified as a minor injury, its common occurrence, the interference with respiration, together with the unsightliness produced, merit more careful consideration, especially as its correction can only be accomplished surgically.

This paper is limited to the treatment of unreduced nasal fractures 6 to 12 months after the injury, in which part or all the nasal elements have settled in abnormal relations, and where the original form of the nose can be restored only by a series of procedures which include mobilization, relocation, and maintenance in a normal position.

TREATMENT.—Anesthesia. The field of operation is walled off with 30 to 40 cc. of a 1 per cent solution of novocain with the addition of 10 drops of a 1-1000 solution of adrenalin to each 30 cc. Three intradermal wheals are raised, one at the junction of the bony and cartilaginous dorsum and one on the side of each ala. A preliminary freezing with ethyl chloride allays the apprehension occasioned by the initial hypodermic. The infratrochlear, supratrochlear and external nasal branches of the ophthalmic supplying the root of the nose, the glabella, and lateral walls are infiltrated by inserting a long needle into the dorsal wheal, the solution being delivered slowly as the needle advances toward the root of the nose. It is carried laterally to the junctions of the nasal bones with the maxillae, where infiltration is continued under the periosteum. The external nasal branch of the infra-orbital supplying sensation to the skin on the side of the nose and mobile septum may be blocked at the infra-orbital foramen located ½ cm. below the midpart of the lower margin of the orbit and about 2½ cm. from the midline of the face on a line with the pupil of the eye. The nasal branch supplying the mucous membrane and skin of the alae, apex of the nose, columella and floor of the anterior nares is infiltrated by inserting a shorter needle into the lateral wheal and working from the apex down to the alar base. The septum is anesthetized by the surface application of pledgets of cotton wrung dry of a 10 per cent cocain solution applied against the septum.

TECHNIC.—Once the diagnosis of the displacement has been made and the reduction to be attained has been settled in the mind of the operator, the procedure may be followed by the drawings and is both simple and rapid. The operative manipulation should not last more than an hour, and the period of hospitalization should not exceed three or four days.

Approach to the Nasal Framework.—The tip of the nose is retracted with the left thumb and index finger, and a double-edged scissors is intro-

duced into the left vestibule between the upper and lower lateral cartilages about midway between their anterior and posterior margins, care being taken to incise the aponeurosis connecting the two cartilages without injuring them. The advantage of this incision is that it follows anatomic raphés and prevents severance of the angular and septal branches of the superior labial artery. The point of introduction of the scissors may be easily located by the anatomic shelf formed by the lower margin of the upper lateral cartilage when the tip of the nose is retracted, the incision being made along the lower margin of this shelf. The blades of the scissors are separated for a distance of 1½ cm. (Fig. 1).

Through this intranasal incision a scissors curved on the flat to accommodate itself to the convexity of the nasal curve, beveled to protect the skin, and sharpened on both sides, is carried beneath the skin over the upper lateral cartilage but not over the nasal bone. By opening the scissors the skin is undermined laterally to the nasofacial fold and medially to the dorsum of the nose (Fig. 2). The same procedure is repeated on the opposite side through a similar incision. The bleeding at this time is controlled by introducing tampons wrung out of a 1-1000 adrenalin solution.

Separation of the skin from its underlying structures is necessary to afford freedom for redressment. It should be completely separated over the line of fracture. It is advisable not to carry the separation much beyond the malpositioned bones because the trauma of extensive separation results in delayed convalescence. Due to the inherent elasticity of the skin it readily readjusts itself to the reconstructed nose.

After detachment of the skin from its subjacent structures, the periosteum next demands consideration in order to expose the bone. Through the initial incision a small periosteal elevator is introduced, engaging the periosteum at the caudal margin of the nasal bones. With a to and fro movement of the elevator it will be found that the periosteum strips easily from the bone (Fig. 3).

Following the separation of the soft parts and in order to obtain a better exposure, a scalpel is introduced through the initial left incision, passed directly over the anterior margin of the septal cartilage, turned at right angles to follow the course of the caudal extremity of the septum, and brought out through the incision on the opposite side (Fig. 4). The membranous septum is cut through about half way to the nasal spine. Completion of the incision is facilitated by replacing the knife by a scissors and cutting the membranous septum down to the nasal spine. With the nasal arch exposed there are many expedients, each dependent upon the nature of the deviation in the elements of the framework.

Management of the Osseous Structures.—(1) Should the nasal dorsum show irregularity due to ossification in an overriding positon, the dorsal line must be straightened. A nasal saw is introduced through the initial incision and placed flush with the irregularity at the exact level at which the profile is to be reduced. The thumb and forefinger of the left hand are

placed on the side of the nose in order to protect the skin and prevent the saw from slipping. With a few vigorous thrusts of the saw the bony and cartilaginous elements and perpendicular plate of the ethmoid are cut through

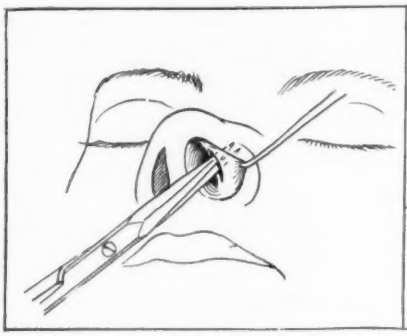

FIG. 1.—Incision between upper and lower lateral cartilages.

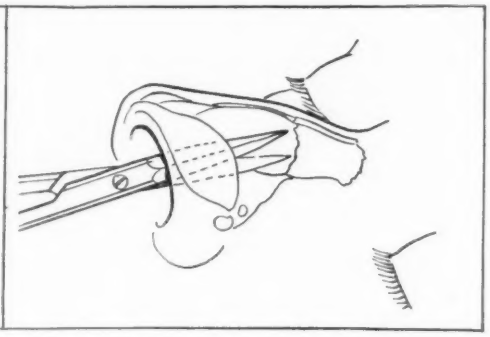

FIG. 2.—Separation of the skin from subjacent structures.

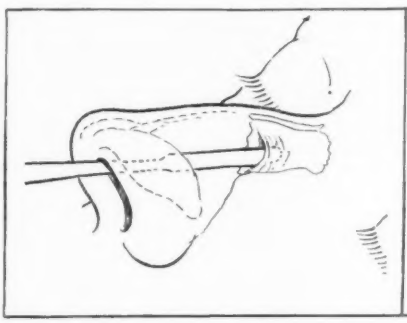

FIG. 3.—Separation of the periosteum from the nasal bones.

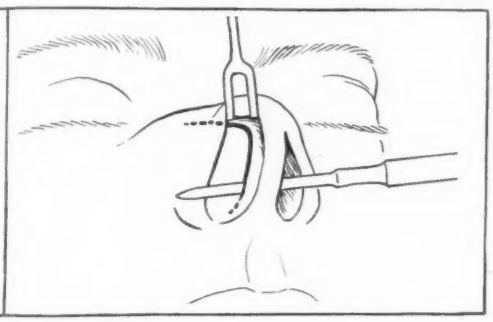

FIG. 4.—Course of the scalpel in transfixion.

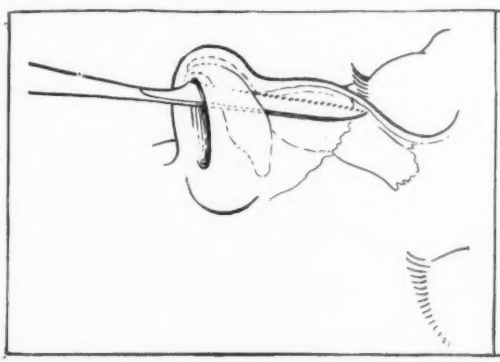

FIG. 5.—Saw reducing the irregularity to straighten the dorsum.

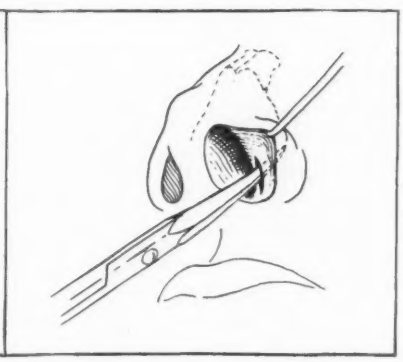

FIG. 6.—Vestibular incision for the lateral osteotomy.

(Fig. 5). The saw is removed and the same procedure is repeated on the opposite side. A knife is introduced under the cut bony section and is drawn downward to the tip of the nose, thus completely freeing all remaining attachments. After removing the knife, the section of bone and cartilage

so liberated is extracted with a stout forceps. All irregularities of the bone and cartilage which now remain are smoothed off with a rasp.

The excision of a stratum of bone to eliminate the irregularity results in a flat triangular defect whose apex points toward the nasal arch, the lateral walls standing out vertically on the maxilla. This defect must now be closed. A double-edged scissors is thrust into the mucosa of the vestibule at the nasobuccal junction and forced through the soft tissues until the pyriform opening is felt (Fig. 6). The skin and periosteum are elevated as before. The saw is introduced beneath the periosteum and is placed in the nasofacial groove, the base of the saw being positioned at the outermost margin of the pyriform opening and the apex resting midway between the orbit and the glabella (Fig. 7). The position of the saw is maintained with two fingers of the opposite hand. Then with an up and down movement

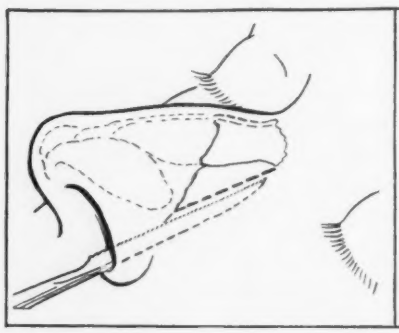

FIG. 7.—Incision for the lateral osteotomy.

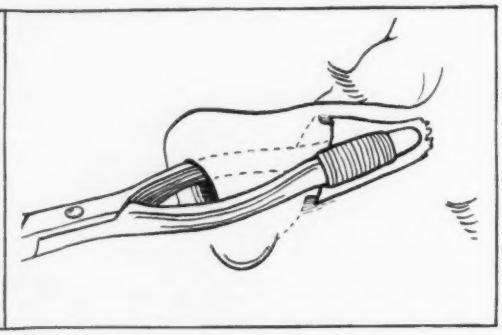

FIG. 8.—Incised bone grasped and with a rotary movement nasofrontal suture is separated.

the bone is sawed through about two-thirds of its thickness, being careful not to pierce the mucosa.

At this stage a Walsham forceps is employed. The outer larger blade (covered with a rubber tubing to prevent injury to the skin) is applied to the outer lateral surface of the nose and the inner smaller blade is introduced into the nasal fossa and held against the under surface of the incised bone (Fig. 8). By a gentle rotary movement the narrow articulation at the nasofrontal suture is separated. So freed, there is no restriction to shifting the boney lateral walls obliquely to the midline, eliminating the dorsal broadness following removal of the irregularity and raising the bones to a degree necessary to reestablish the line of the arch. The mobilization is not considered complete until the nose will remain in the proper position after reduction without support.

(2) It has been demonstrated in the foregoing that where the excessive width of the bridge follows the removal of irregularities, sufficient space has been created along the dorsum for the nasal bones to be shifted to a more central position, and this is accomplished by mobilizing the frontal process of the superior maxilla; but in cases where the abnormal width follows a traumatic separation of the nasal bones without irregularities, before

the nasal bones can be narrowed the spring of the nasal arch much be broken. This is accomplished by introducing a saw into the initial incision and cutting the nasal bone on each side of the osseous septum at the junction of the anterior and lateral aspects of the osseous arch, sawing diagonally toward the nasal process of the frontal bone. After performing the lateral osteotomy through the frontal processes of the superior maxillae in the manner already described, the bones can be brought into a central position, thereby narrowing the bridge (Fig. 9). Traumatic exostoses of the nasal bones or frontal processes of the superior maxillae are planed off with a chisel introduced into the intercartilaginous incision.

(3) Where the force has been applied from in front with impaction and depression resulting in the traumatic saddle nose, the method of correction will depend upon (a) the amount of depression, (b) the existence of cicatri-

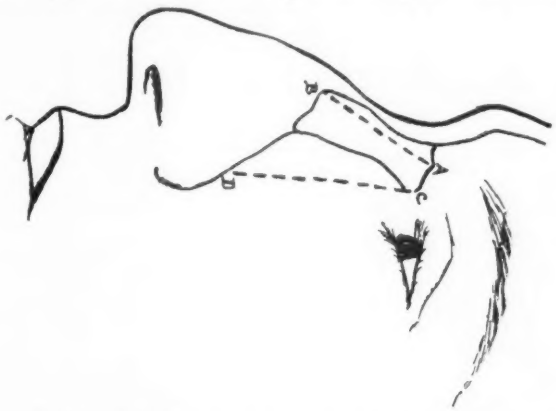

FIG. 9.—A-B line of saw cut on each side of dorsum to break spring of nasal bones. C-D lateral incision to mobilize fragments.

cial tissue, and (c) whether or not the deformity involves the bony or the cartilaginous vault, or both.

Reconstruction of the dorsum by readjustment of the nasal structures already present is the ideal procedure. A slight degree of depression of the bony dorsum may be corrected by an osteotomy of the frontal processes of the superior maxillae. After separating the bones at the nasal and frontonasal sutures, the lateral walls are elevated somewhat, thus overcoming the slight depression.

Correction of a moderate depression of the upper cartilaginous vault may be accomplished by separating the upper lateral cartilages from the maxillae and from the septal cartilage, raising them to the required height, and fixing them by a suture placed below their anterior margins, the depth of the suture depending upon the amount of elevation necessitated. Or, the defect may be filled in by pieces taken from the upper or lower lateral cartilages. When material for reconstruction of the arch is not available in the immediate vicinity it may be obtained from cartilage of the ear or rib, depending upon the amount required.

Measurements are taken from the infraglabellar region to the nasal tip and from the tip to the spine of the superior maxilla. The precise length and width of the cartilage required is thus determined. A piece of cartilage indicated by the measurement is removed from the seventh, eighth, and ninth rib cartilages where they spread into a wide plaque. It may comprise the entire thickness of the cartilage or only a part, in which case the excision is facilitated by the use of a woodcarver's chisel (Fig. 10). As soon as the cartilage is removed it is shaped to fit the defect and inserted through the original incision (Fig. 11 (a) and (b)). Circumstances may call for modification in the technic. For example, a scar over the bridge may limit the possibility of undermining the tissues in order to prepare a bed for the transplant. In this case the cartilage may be introduced externally through the opening made by excision of the scar.

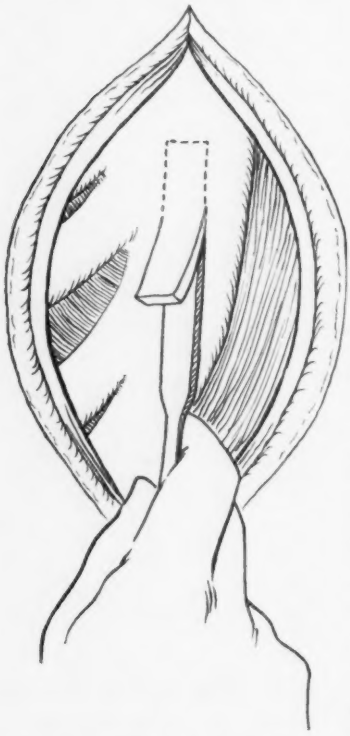

FIG. 10.—Removal of rib cartilage with chisel.

(4) When the blow has been applied laterally and results in a shifting of the dorsum from the midline of the face, in order to bring the nose into a median position room must be created by removing a triangular section of bone from the broad, concave side so that the narrow convex side may be shifted into a median position and so straighten the dorsum. A lateral osteotomy is performed in the manner already described except for a triangular ostectomy on the concave, or wide side (Fig. 12). The size of the triangle should equal the angle of deviation from the normal. Before the triangular piece of bone can be removed it will be necessary to separate the mucosa from its under surface. The triangle of bone now freed is grasped with a pair of stout forceps and removed.

With both thumbs on the convex side of the nose (protected by a gauze pad) and the fingers placed against the opposite zygoma the nose is forced into the space created by the removal of the triangular section of bone. Fracture at the nasofrontal suture takes place through the force applied to the convex side. It is important that not only the nasofrontal suture be fractured but also the perpendicular plate of the ethmoid in order to avoid the tendency to recurrence of the deformity.

The Upper Lateral Cartilages.—After the bony arch has been repositioned in its normal location it will be found that the upper lateral cartilages require attention. With the aid of a retractor they may be inspected. If they are widened as a result of the traumatic separation of the nasal bones a strip of cartilage is resected close to the dorsum sufficient to correct the deformity.

They are then replaced in their proper anatomic locations and immobilized by one or two catgut sutures (Fig. 13). They may be thickened or buckled from chondritis, in which case they should be reduced by shaving with a sharp scalpel.

The Lower Lateral Cartilages.—The same trauma that produced the nasal

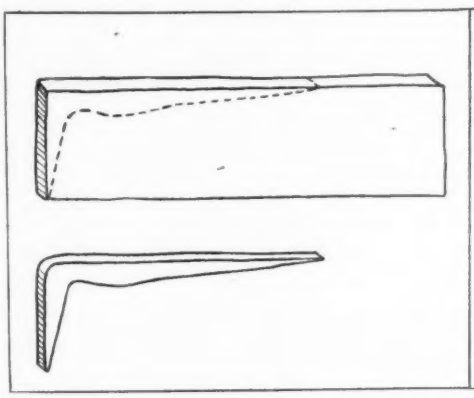

FIG. 11A.—Modeling of cartilage.

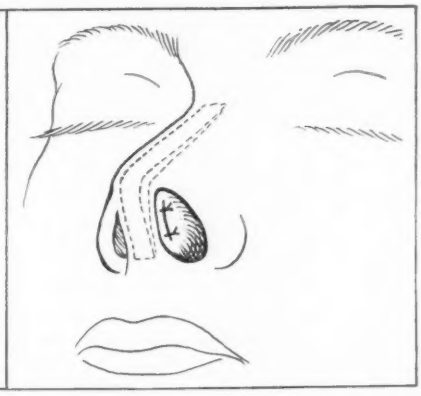

FIG. 11B.—Cartilage in place to overcome the saddle.

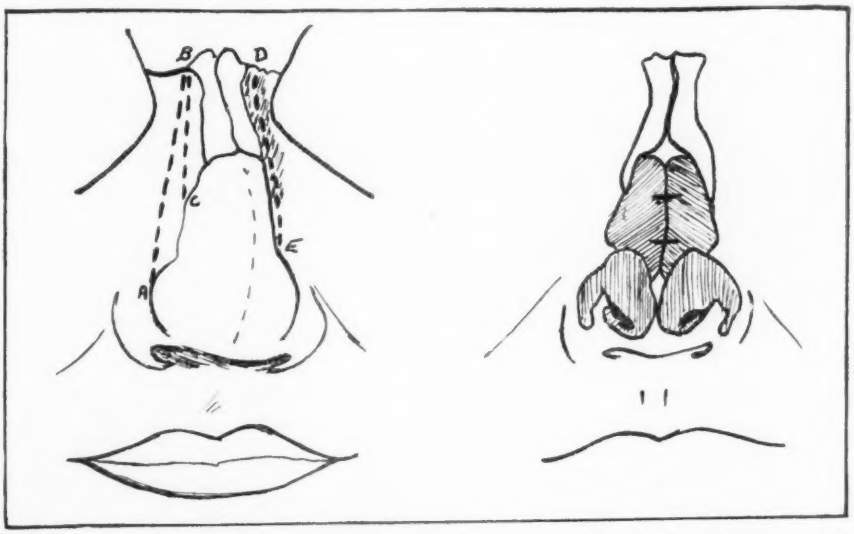

FIG. 12.—A-B-C—Triangular ostectomy on concave side to create room to shift nose into a medial position. D-E—Saw cut for lateral osteotomy.

FIG. 13.—Upper lateral cartilages brought into the midline and immobilized by two catgut sutures.

fracture may be expected to bring about various fractures and displacements in the lower cartilaginous vault. The angles of the lower lateral cartilages produce the curve at the tip of the nose. They may be widened, producing a wide tip. They may be separated, producing a cleft tip. One or both of the cartilages may be hypertrophied, buckled or displaced, producing a twisted tip. These cartilages must now be treated in order to harmonize with the balance of the reduction. The method employed is as follows:

An incision is made in the vestibule just below the inferior margin of the

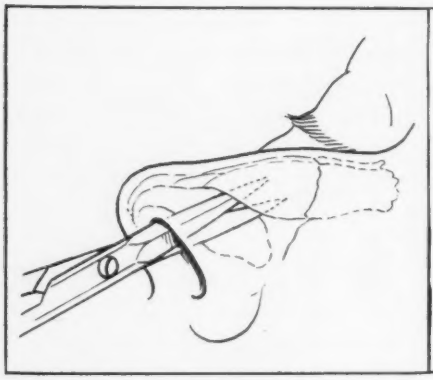

FIG. 14.—Exposure of the lower lateral cartilages (separation of external skin).

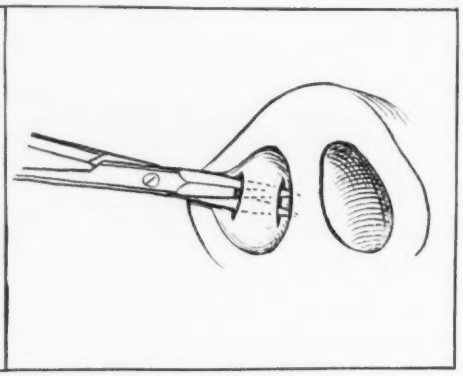

FIG. 15.—Exposure of lower lateral cartilages (separation of vestibular skin).

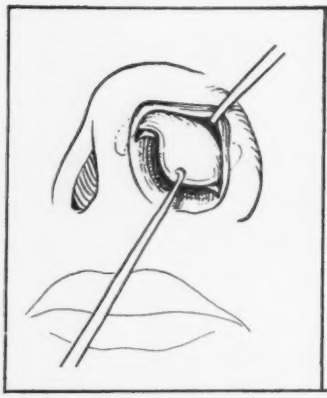

FIG. 16.—Delivery of lower lateral cartilage.

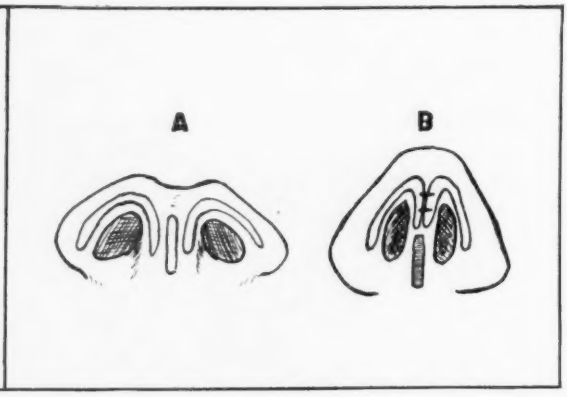

FIG. 17.—(A)—Dislocated lower lateral cartilages. (B)—Lower lateral cartilages brought together and sutured.

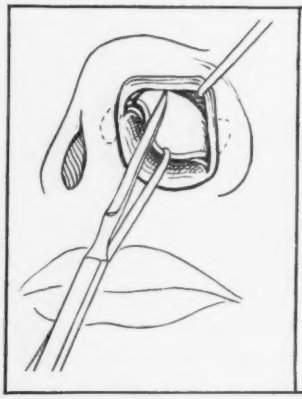

FIG. 18.—Removal of angle to diminish width.

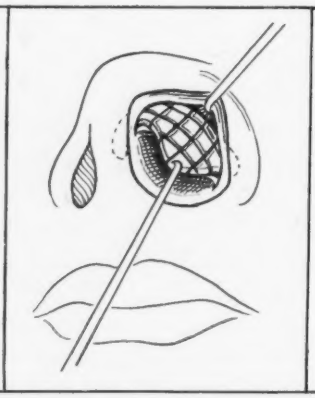

FIG. 19.—Ribbon incision to remove spring of cartilage.

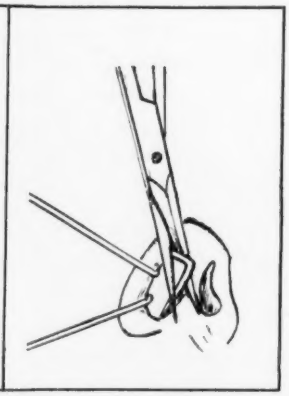

FIG. 20.—Excision of the caudal end of the septum to reduce the length of the nasal pyramid.

lower lateral cartilage. The double-edged scissors mentioned above is introduced into the incision and brought out through the initial intercartilaginous incision, the scissors lying between the external skin and cartilage (Fig. 14). By opening the scissors the tissues are separated laterally to the posterior termination of the alar crus and medially to the septum. The cartilage is also freed from the skin lining the vestibule by the same procedure except that now the scissors lie between the cartilage and the vestibular skin (Fig. 15). Being so freed, the cartilage is withdrawn from the vestibule by a single-hook retractor and dealt with as the pathology may indicate (Fig. 16).

If the angles are separated, they may be brought together and held in place by a suture (Fig. 17, (a) and (b)). If they are too wide, a strip of cartilage is removed from the angle (Fig. 18). The length and width of the excision will be governed by the extent of the reduction it is required to make. The separated parts of the lower lateral cartilage fall into the midline and the reduction of the width of the tip of the nose equals the combined width of the sections of cartilage removed. If the cartilages are hypertrophied, buckled or displaced, this traumatic pathology may be overcome by shaving or cutting them in a ribbon formation to destroy their spring, and repositioning (Fig. 19).

The Septum.—The operative procedure as applied to the septum must be dictated by the conditions found. The problem is to restore the septum as a partition in the median line causing no occlusion of the air passages; to relocate the caudal margin on the floor of the nose in order to give form to the columella; and to bring the anterior margin into a straight line so as to project the dorsal margin at an angle of 30° from the face.

Frequently the septum springs back into the correct position when the nasal arch has been repositioned without further manipulation. But should excision be necessary it may be done in the usual manner, care being taken to leave sufficient buttress to maintain the outline of the nose. A submucous resection should not be performed until the bony and cartilaginous arches have been reestablished; otherwise it may be found that when the dorsal irregularities are excised there is not sufficient support for the dorsum.

Occasionally a blow applied from in front or from the side may separate the upper lateral cartilage from its nasal attachment or fracture the body of the septum with downward displacement, the interval between the separated parts being replaced by organization. This results in elongation of the nasal pyramid. Shortening may be easily brought about in the following manner: The columella is retracted to one side, exposing the lower end of the septum through the nostril. The caudal ends of the lateral cartilages are separated from their attachments to the septum. The lower end of the septum is steadied with a forceps and as much of the exposed part as desired to produce the necessary shortening is excised with scissors (Fig. 20). After shortening the septum it will be found that the upper lateral cartilages are too long and protrude through the original incision. The protruding portion is excised with a curved scissors in such a manner that the edges of the incision again fall into apposition. The whole procedure is terminated by attaching

the columella to the cut end of the lower edge of the septum. A suture is passed ½ cm. below the anterior edge of the septum, the needle passing through the mucosa and cartilage on both sides, through the columella, and

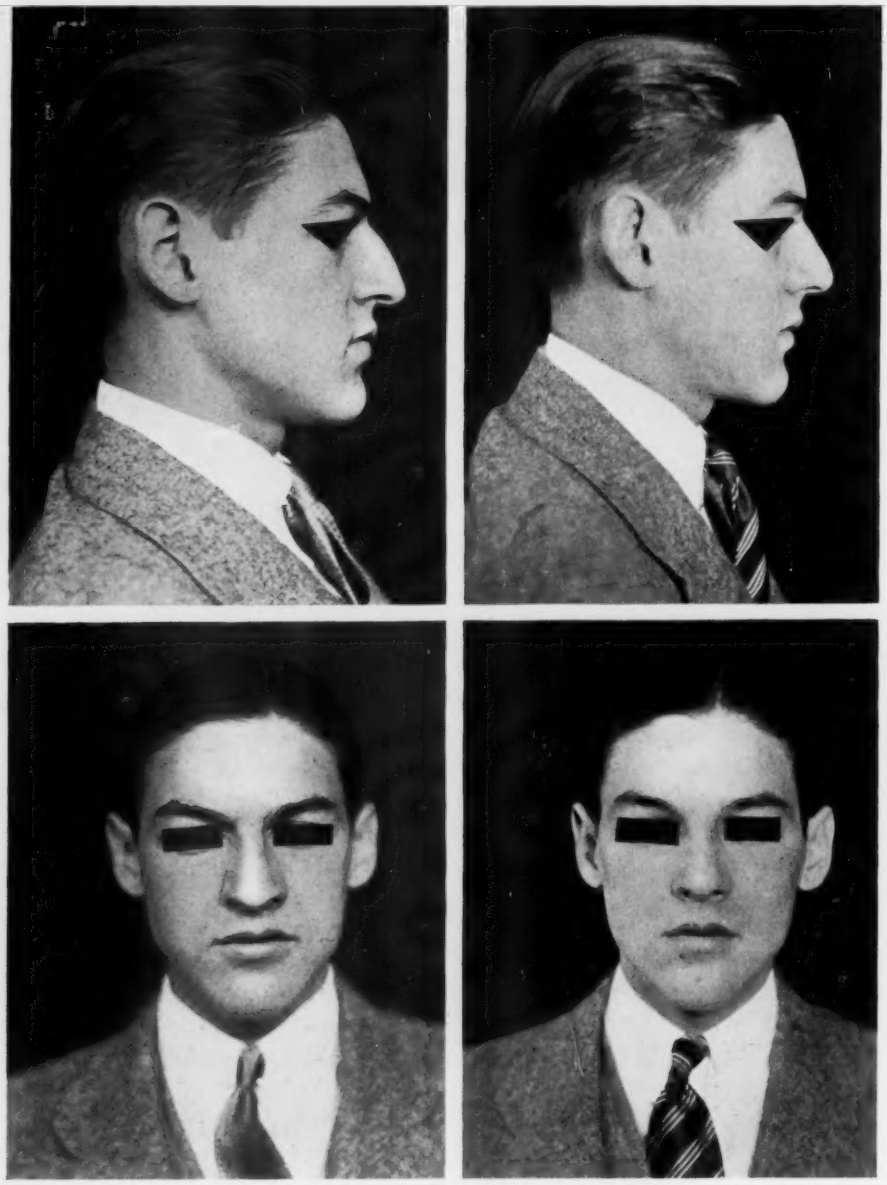

FIG. 21.—Traumatic separation between osseous and cartilaginous dorsi with separation of the upper and lower lateral cartilages. Front and side views.

tied. A second suture is passed in a similar manner just above the nasal spine and through the columella.

Immobilization.—If the nasal arch has been properly mobilized and set, theoretically, splinting is not necessary as there are no muscles capable of

causing redisplacement; but practically, for the first 48 hours it is desirable to put on a Stent dressing to offset the possibility of disturbance by the patient in the early postoperative period. At the end of 48 hours the splint is

FIG. 22.—Fracture with union in an overriding position.

FIG. 23.—Fracture of the septum with a dislocation backward.

discarded, the xeroform packing is removed, and the nostrils cleansed of incrustations with hydrogen peroxide. The nose is kept lubricated with sterile albolene. The patient is allowed to sit up in bed on the third day, discharged on the fourth day, and is instructed to return to the hospital for the removal of the two sutures on the fifth or sixth day.

DISLOCATION AND ELONGATION OF THE LONG HEAD OF THE BICEPS BRACHII*

AN ANALYSIS OF SIX CASES

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DISLOCATION and elongation of the tendon of the long head of the biceps brachii were mentioned as belonging to the symptom-complex previously described.[29] This lesion is supposed to be rare unless accompanied by severe injuries to the shoulder girdle. Many cases found at autopsy have been reported in the literature.[1, 5, 12, 16, 22, 63, 67] Numerous others have been recorded as having been seen clinically,[3, 13, 17, 20, 30, 34, 39, 46, 50, 52, 69] but not operated upon. Up to the beginning of this century the opinions of the various authors have frequently been in disagreement, some citing cases which, without doubt, were clinical instances of traumatic simple luxation of the tendon[13, 17, 19, 20, 24, 30, 31, 32, 34, 39, 40, 46, 50, 52, 53, 54, 65, 68, 69, 70] and others doubting or denying such luxation altogether,[4, 26, 35, 41, 44, 51, 55, 58] but conceding the possibility of a dislocation, the result of chronic arthritis[1, 5, 12, 16, 21, 63, 64, 67] or a complication of other severe lesions (fracture, dislocation, *etc.*) of the shoulder.[32, 40, 44, 46]

Commenting on the divergency of opinions of the cases reported, White,[70] in 1884, stated: "Although for more than 100 years cases of supposed luxation of the tendon of the long head of the biceps muscle have been reported or alluded to by surgical writers, yet they have been so poorly observed or so carelessly described, that they fail altogether to carry conviction, the one case which possesses any strong element of probability being itself open to reasonable doubt."

Meyer[48] and his associates have found over 50 cases of marked dislocation of the tendon of the long head of the biceps and many others of lesser degree in the dissection of 1,000 arms. Some of these were bilateral. I have had four clinical cases, one successfully operated on† and three under observation. In addition I have analyzed two other cases through the courtesy of Dr. Edward Bull.[11]

Literature.—In a complete review of the literature I find no mention of an operation having been performed for the relief of this condition. It has been an alluring subject for thought and discussion, nevertheless, and has arrested the attention of some of the greatest surgeons from the time of Hippoc-

* Read before the Western Surgical Association, St. Louis, December 8, 1934.

† This was in 1926 and as far as I have been able to determine is the first uncomplicated case reported of an operation to relieve this condition.

rates, 59 of whom have recorded their opinions. Because of the length of this most interesting history, I have placed it as an appendix to this report.

Anatomic Considerations and Causes of Dislocations.—A consideration of the anatomic structures which form the intertubercular sulcus (bicipital groove), and the course of the tendon within the sulcus and the capsule, readily reveals that the direction of the tendon varies with the position of the arm

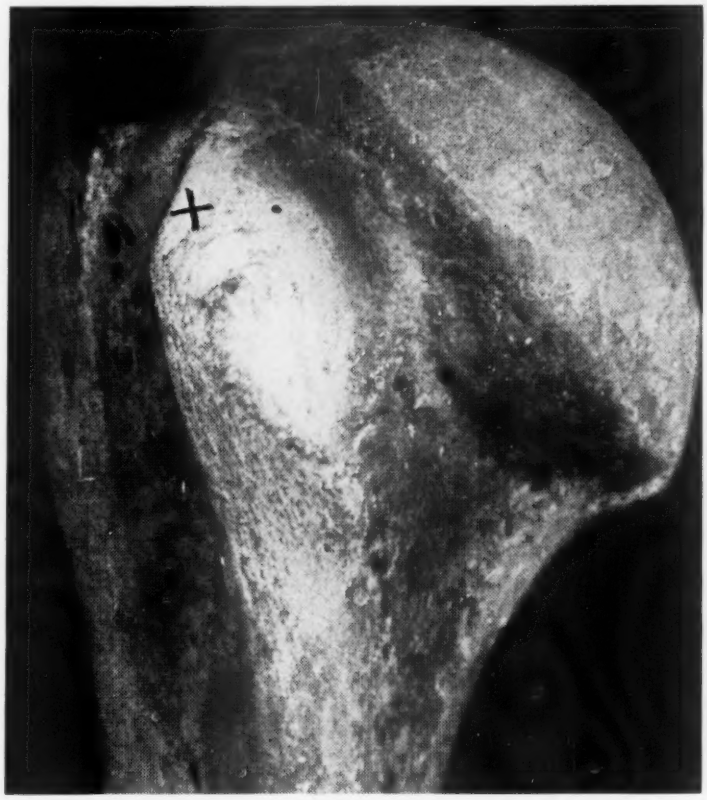

FIG. 1.—Portion of a right humerus with a supratubercular ridge marked X. This bony ridge extends obliquely forward and downward from the region of the articular cartilage to the upper and dorsal portion of the lesser tuberosity. As the surface of the distal extremity of this ridge is on a level with the surface of the latter, and since the tendon plays on it much as the tendon of the peroneus longus plays on the trochlea of the cuboid, its rôle in dislocation is plainly evident. In a study made by Cilley (unpublished) it was present in 17.5 per cent of 200 humeri. (I am indebted to Dr. A. W. Meyer, Professor of Anatomy, Stanford University, for this photograph and the explanation of it.)

(Figs. 1, 2, 3). With the arm at rest, Bera[6] has pointed out, "the tendon is almost horizontal in its intra-articular course and has, in the groove, a vertical direction; its course follows the lines of a right angle with rounded angle at the level of the lesser tuberosity, on the slope of which it rests to be reflected and to slide at the contraction of the biceps. The angle formed by the intra-articular and extra-articular portions of the tendon varies, and according to the different attitudes and positions of rotation of the arm, the tendon is re-

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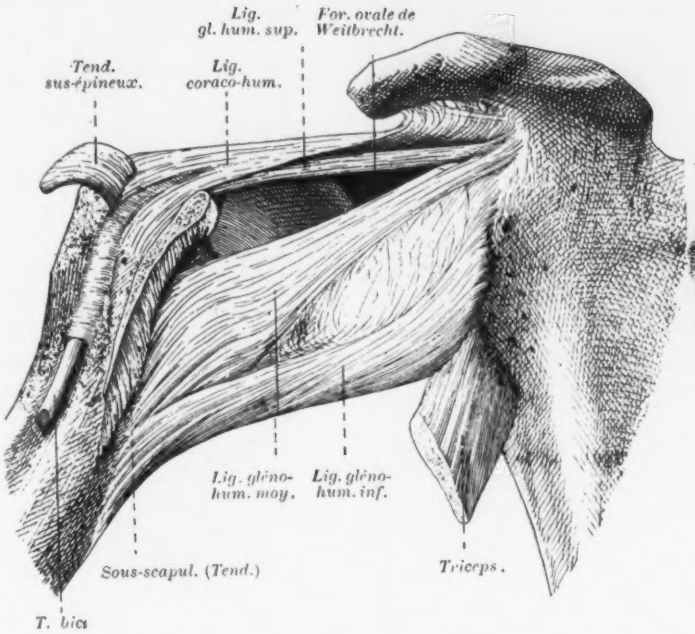

FIG. 2.—Anterior view of shoulder joint showing relationship of tendon of long head of the biceps to articular capsule. (From Poirer's and Charpy's Human Anatomy.)

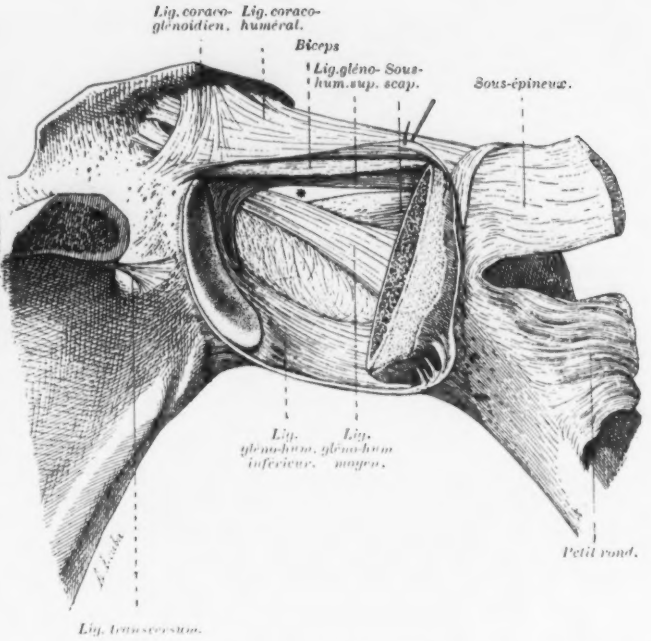

FIG. 3.—Posterior view of the shoulder joint showing relationship of the tendon of the long head of the biceps to the articular capsule. (From Poirer's and Charpy's Human Anatomy.)

flected on either tuberosity or against the transverse humeral ligament which forms the roof of the osteofibrous tunnel of the bicipital canal."*

On the other hand, the head of the humerus has a rounded and polished surface. The tendon curves over it anteriorly and mesially, and at that point it broadens and flattens out. This is an anatomic and a physiologic factor for its dislocation. The tendency to dislocation is further increased by the fact that contraction of the biceps muscle puts the tendon of the long head under tension and the curvature, which the tendon has over the head of the humerus when the arm is more or less adducted, tends to straighten out, "while the head of the humerus is pushed downwards and backwards."[47]

According to Meyer,[47] "In all normal joints there are three, and there may be six, factors which favor dislocation of this tendon: (1) the normal course of the intracapsular portion of the tendon and its relation to the humeral head; (2) the much greater width of the proximal portion of the tendon; (3) the fact that the anterior wall of the sulcus which is formed by the lesser tuberosity normally acts as a trochlea for the tendon in the usual position of medial rotation; (4) a supratubercular ridge may be present; (5) the capsular attachment may be weakened by intracapsular bursae, and (6) the capsular attachment to the anatomic neck in the region proximal to the lesser tuberosity may be restricted."

He believes that "the tendency to dislocation of this tendon, which exists in all normal shoulder joints, is opposed primarily by the attachment of the articular capsule in the region proximal to the lesser tuberosity" and by the medial ridge of the sulcus which sometimes is very steep. He does not agree with most anatomists that the transverse humeral ligament plays an important rôle in preventing this dislocation and has accumulated conclusive evidence, in his dissections, that the partial dislocation of the tendon of the long head of the biceps brachii is a surprisingly common condition. In a number of his specimens the capsule is entirely intact though it has stretched, forming a sling around the dislocating tendon so that the tendon lies partly or wholly upon the lesser tuberosity, using it as a trochlea (Figs. 4 and 5). To quote Meyer, it is interesting that "since the surface of the lesser tuberosity is normally rough, the under surface of the tendon will show evidence of wear unless protected by this capsular sling, the deeper portion of which forms a cushion for the tendon. If this wear progresses, it weakens the tendon and may ultimately destroy it to the extent that a rupture may follow."

Another factor which undoubtedly plays an important rôle in the dislocation of the tendon was first described by Bera,[6] who showed that a malforma-

* As Meyer[47] has said: "When the arm is in slight lateral rotation, the under surface of the tendon lies fully on the floor of the sulcus; but as lateral rotation is increased its anterior margin is forced against the anterior wall of the sulcus, especially that portion formed by the lesser tuberosity and the capsular attachment proximal to it. In medial rotation, on the other hand, the anterior wall of the sulcus and the adjacent capsular attachment become the surfaces which the tendon uses as a trochlea, while its dorsal margin is forced against the dorsal wall of the sulcus."

FIG. 4.—This shows how clearly the yielding of the capsular attachment in the region of the lesser tuberosity permits the long head to be dislocated anteriorly, or downward, and explains the relaxation of the tendon often spoken of as the elongation of the tendon. (Kindness of Dr. A. W. Meyer, Professor of Anatomy, Stanford University.)

FIG. 5.—A right humeroscapular articulation with the tendon reflected anteriorly to reveal its bed. The proximal portion of the intertubercular sulcus is seen to the left of the new bed of the tendon. This tendon, which lies in a capsular sling, had passed practically over the lesser tuberosity but still occupied the sulcus distal to the intertuberosital region. (Kindness of Dr. A. W. Meyer, Professor of Anatomy, Stanford University.)

tion or a localized osteitis reduces the volume of the lesser tuberosity and favors the luxation of this tendon. He also believed that this tendon can be dislocated by a violent muscular contraction, particularly in the presence of preexisting arthritis. When this tendon slips over the lesser tuberosity the tension of the muscle is immediately lessened and we have what is known as the typical relaxed tendon, producing the classical bicipital syndrome.

Arthritis, however, is not always a preexisting factor in dislocation, as proved by Meyer. In a remarkable specimen revealing a bilateral dislocation of the tendon, that of the right arm was much farther luxated than the left, it having passed completely over the lesser tuberosity, while the tendon of the left arm had luxated only to the top of the tuberosity. Consistent with the condition found in other specimens of dislocated tendons of the long head of the biceps, there was not the slightest evidence of arthritis.

Types of Dislocation.—Bera[6] also pointed out that, while the tendon may and does "dislocate forward, it may also dislocate posteriorly, completely or partially. The complete dislocation involves the opening of the bicipital groove and the local detachment of the articular capsule. The violence capable of producing this disorder will more likely produce the rupture of the tendon or the dislocation of the shoulder. But these cases of posterior dislocation are not related to the bicipital syndrome." According to the onset, the dislocation may be acute, gradual, or recurrent. The acute and recurrent types are rapidly disabling, for the period of their duration, while the gradual type may not be disabling at all except for a more or less vague discomfort in the shoulder which often is interpreted by the patient and the physician, as being rheumatic in origin.

Mechanism of Production.—The mechanism of production of the acute and recurrent types of luxation is brought about by external rotation and abduction of the arm over 90 degrees, in which position the tendon is reflected more, over and against the attachment of the articular capsule in the region of the lesser tuberosity. According to Borchers,[8] the production of the osteophytic outgrowths in and around the bicipital groove, the result of arthritis, may be such that the groove will be filled and thus the tendon becomes mechanically dislodged. Gurlt[33] reports one such case of dislodged tendon. Meyer[48] discussed the various factors which favor a dislocation of the tendon and came to the conclusion that it may be the result of occupation.

Symptoms.—Symptoms of a dislocated tendon are variable and depend on the onset and type. In most cases they are similar to those of a ruptured biceps tendon.[29] The onset is usually acute. There is pain in the region of the bicipital groove, which may radiate down the muscle. This pain is increased on external rotation and overhead extension. There is also weakness of the arm. The pain and the weakness may be so marked that the function of the limb is very much impaired.

If the dislocation has been complete, the tendon of the long head of the biceps has, according to Bera[6] "a direction more inclined than usual in regards

to the axis of the body," and "with the arms horizontally, in cross-like fashion, the direction of the external bundle of the biceps ends in front and not over the glenoid cavity." This sign may be visible, of course, only in thin, muscular persons.

An apparent elongation of the long tendon may be seen, evidenced by a slight flabbiness of the muscular belly which may be lowered.

Palpation of the tendon outside the groove, or of the empty groove, is pathognomonic, although these signs cannot be elicited in many cases because of the overlying structures. A change in direction may be more easily detected. If the onset has been gradual or if the tendon has slipped forward slightly, the symptoms and signs are not very striking. There may be a vague soreness in and about the groove, which is increased by movements of external rotation and overhead extension.

Diagnosis.—A diagnosis is not always made easily, especially if one does not bear this entity in mind during the examination of a shoulder. The symptoms may not be very pronounced at first and many of the objective signs may be obscured by the tenosynovitis and the generalized soreness which result from the production of such a lesion. The history is very valuable. In any disability of the shoulder, brought about by a sudden movement or by movements of external rotation and overhead extension, continued over a long period of time, the possibility of the production of a dislocation of the tendon of the long head of the biceps should always be considered.

In case of a dislocation, if the onset is acute, there is marked weakness of the arm and pain, more marked on movements of external rotation and overhead extension.

On inspection, if the subject is thin and has a well-developed musculature, one may detect the changed direction of the tendon of the long head of the biceps which, with arms raised horizontally, appears to run anteriorly and more mesial than normal.

The apparent elongation of the tendon with lowering of the belly may be present but difficult to recognize because of the reflex spasm of the muscle, especially if the injury is recent or the dislocation not very severe. Palpation will confirm what inspection has revealed and often is the only means of arriving at a diagnosis.

Diagnostic Test.—We have found the following test very useful in verifying the diagnosis of dislocation of the tendon. If there is a recurrent dislocation of the tendon (Cases II and IV), one can at times reproduce the dislocation by having the patient bring his extended arms to overhead extension and marked external rotation holding, if possible, an equal weight in each hand, such as five-pound dumbbells (Fig. 6). The observer places himself either behind or in front of the patient and puts his fingers on the long head of the biceps. The patient is then instructed to lower his outstretched arms to the side in the coronal plane. When the arms reach an angle of from 110 to 90 degrees, a definite snap may be audible in the top of the injured shoulder and a sharp pain is elicited both in the shoulder and in the region of the

bicipital groove. This snap is also felt by the fingers held over the belly of the biceps and the tendon of the long head. It gives the impression of a taut violin string that snaps as it slips into a groove of the bridge. Occasionally the vibrations produced by the snap may be visible in the long head of the biceps. This snap is not produced if the arm is lowered in internal rotation, or if the belly of the biceps, or the tendon of the long head is held and pushed firmly posteriorly, even though the arm is in external rotation. Since developing this test, I have found it present in my last three cases.

A diagnosis of a dislocated tendon can be made if one considers the mechanism of production of the injury and is careful in accounting for the various signs and symptoms. If the dislocation is not complete and recurring (Case III), the snap may not be detected so plainly. Then one has to rely upon the patient's subjective symptoms which are more severe when the arm is in external rotation and less so when it is in internal rotation or when the

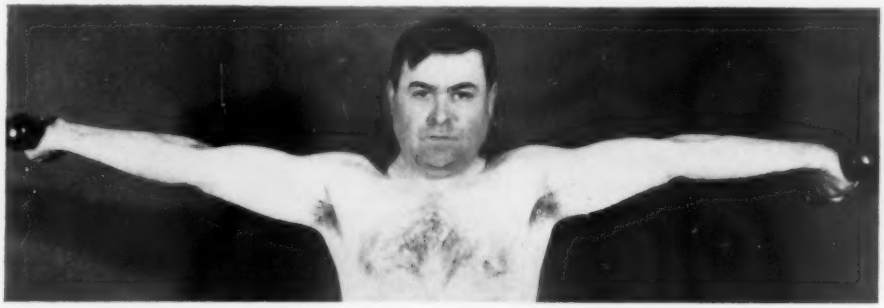

FIG. 6.—(Case II.) Diagnostic test. See text for details.

tendon is pulled outward and posteriorly so that it does not reflect itself on the anterior structures of the groove and on the lesser tuberosity. In Case III, we verified this point, checking also with the other signs of Hueter[40] and Yergason[71] which are both definitely positive as long as the tendon, brought into contraction, is not held back and outward. If one exerts outward pressure on the belly or, better still, on the tendon as high as possible under the anterior border of the deltoid muscle, these signs, even though they do not become entirely negative, elicit less pain.

Whether the tendon dislocates or ruptures and takes up a new and necessarily lower attachment in or along the edge of the intertubercular sulcus, the belly or muscle loses some of its tone and undergoes more or less atrophy. This explains why, at operation, although the tendon is of normal size and consistency, the muscle is flabby and can be lifted up much more freely than the short head (Case I).

Differential Diagnosis.—In the differential diagnosis of dislocation of the tendon of the long head of the biceps one must remember that the subjective and objective symptoms are often not very clear. A painstaking examination and repeated observations are frequently necessary before a definite diagnosis is reached. This results from the fact that in the shoulder, and espe-

cially in the region of the bicipital groove, there are so many important structures, one overlapping the other and most of them very deeply situated.

Subdeltoid Bursitis.—As mentioned before,[29] in subdeltoid bursitis the pain and tenderness are localized in the region of the bursa and are increased by passive or active external rotation and abduction. None of the important symptoms of the bicipital syndrome are present.

Soto-Hall and Haldeman[66] emphasized the fact that the injection of novocain into the subdeltoid bursa is a very valuable means of differentiating an injury of the subdeltoid bursa from a tear of the supraspinatus tendon. I have found this to be a useful procedure.

Rupture of the Supraspinatus Tendon.—A lesion of this tendon should not be mistaken for a dislocation of the long head of the biceps. For a complete study of the supraspinatus tendon the reader is referred to Codman's excellent book.[15]

The dislocation may be anterior or posterior, but only the former is identified with the bicipital syndrome. The principal signs, of course, are the changed direction of the tendon, palpation of the empty groove or of the tendon outside of it if possible, and the tendon having a more anterior and mesial position. If the dislocation is complete, it may be confused with a rupture of the high type or with an elongation. A detailed history of the onset of the disability and of its mechanism may be helpful, as a luxation has always a forced abduction and external rotation as one of its main factors. In a case of dislocation, the tendon is still under tension, more so than in a rupture, and the muscle therefore is not so flabby. Impairment of function is greater in a dislocation, especially on movements of rotation and slight abduction, and also on those of flexion of the forearm. In a rupture, the movements of flexion are much more impaired than those of abduction and rotation. A rupture of the low type has signs and symptoms distinctly different and it eliminates immediately the diagnosis of dislocation, elongation, or a high rupture of the tendon.[29] If the dislocation is not complete, the diagnosis may be made by the change in the symptoms, that is the lessening of objective and subjective findings when the tendon is held firmly and pushed backward and externally, either by means of the belly or, better, by direct pressure on the tendon under the anterior margin of the deltoid. The high type of rupture may be confused with the true elongation of the tendon, but the latter is rather a rare condition. An apparent elongation is caused, therefore, by a dislocation or a high type of rupture. Thus, by elimination, one can attain a fairly accurate differential diagnosis.[6, 29]

Elongation of the Tendon.—A considerable number of cases of elongation of the long head of the biceps tendon have been reported; most of them, however, were undoubtedly apparent rather than real. A true type of elongation is, according to Bera,[6] the result of numerous ruptures of single fibers in the thickness of the tendon. An apparent elongation is the result of a dislocated tendon or of a rupture of the high type with subsequent lower attachments, or of the low type with the formation of scar tissue between the two

ends of the tendon and subsequent atrophy of the muscular belly. The true type of elongation may become a complete rupture when the tendon, after repeated ruptures of the fibers, gives way completely. Cases of true elongation are very rare, but such an elongation of the upper tendon was reported by Bera,[6] and Holcomb[38] had a case, in which operation revealed that the lower tendon "had slipped down through the muscle very much as the center of a roller bandage is pulled out of the bandage."

Treatment.—If the tendon is dislocated and the patient is seen early, an attempt should be made to reduce the dislocation by the following procedure, which I have used on several occasions. The extremity, with the elbow bent and the forearm supinated in order to relax the tendon, is abducted passively and gently in the coronal plane to 90 degrees or more and simultaneously rotated internally. Sometimes it may be necessary to grasp the belly of the biceps as high as possible, near the deltoid muscle, pull it backward and hold it as the arm is lowered in the same plane, to help the replacement of the tendon and also to prevent a possible, although rare, immediate redislocation. Anesthesia may be required to overcome the reflex spasm of the structures in the shoulder.

If the patient is seen some time after the dislocation occurred the treatment really depends on the subjective symptoms and especially on the disturbances of function. If they are not very severe, it may not be necessary to intervene surgically, as the tendon and the structures around the intertubercular sulcus will have adapted themselves to the new condition. If the patient is engaged in heavy work which requires constant use of his biceps, the best procedure is to operate early as there is every reason to believe that, if he is having trouble a fairly long time after the accident, his condition will not improve, but will probably get worse.

The surgical repair varies according to the operative findings. If the structures around the groove are such that their repair will give assurance of a good result, this should be done, and, if necessary, the groove should be deepened. An easier procedure, and one probably more satisfactory, is to repair the tear in the structures around the groove, after severing the tendon of the long head as high in the joint as possible, and then to suture this tendon to the coracoid process and to the tendon of the short head (Fig. 7) as described previously.[27, 28] This has invariably given a satisfactory result.

Prognosis.—The outlook depends both on the severity of the injury and on whether there are other concurrent lesions of the shoulder girdle. In the latter case the lesion of the tendon is of secondary importance, though when present it should be recognized early and treated as soon as the other injuries have received attention. In case the dislocation is isolated, spontaneous reduction may occur under a sudden movement which returns the tendon to its normal position. In this case soreness may persist for several days. If the reduction is not accomplished soon, newly formed adhesions may fix the tendon to the humerus or the tendon may be reflected in a capsular sling and work through this newly acquired position, as shown by Meyer.[47, 48, 49] In

such a case there may be discomfort and functional disturbance of varying extent, according to the degree of relaxation of the biceps and to the subsequent shortening of the muscle if any, especially to the pulling and tugging on the stretched capsule where it forms the capsular sling.

An acute dislocation requires immediate reduction because of the intensity of symptoms and the duration of disability, if reduction is not accomplished. A dislocation which has developed gradually may not produce many symptoms nor be very disabling.

Coracoid process
Long head of biceps sutured to coracoid process
Chromic catgut sutures
Long head of biceps
Short head of biceps

FIG. 7.—The tendon of the long head of the biceps inserted through the tendon of the short head to which it is sutured, as well as to the coracoid process.

Medicolegal Aspect.—The medicolegal aspect depends, of course, on many factors, especially on the amount of disability which may arise as a result of a dislocation of the tendon and on the time of onset of the disability. There is no question as to industrial liability in the acute type. Its onset and mode of production are very clear. There is question, however, in a luxation which has been produced gradually, as in the case of workers who use their arms in external rotation and abduction, such as painters, carpenters, decorators, miners, fruit pickers, *etc.* Usually many of their symptoms are attributed to arthritis or sprains for a while until they, with a slight effort, stretch the capsule a little more and therefore cause immediate disability. Each individual case, therefore, should be studied carefully, especially if the onset is not sudden. In all fairness to the employee one must not forget that there is, at times, an occupational factor in these cases and that, since the soft tissues in various shoulders give way differently and to a varying degree, the symptoms change from case to case and from time to time in the same patient according to the amount of reaction produced by the injury and often by an examination. In fact, symptoms may appear or disappear on two successive examinations. It is very important and highly essential to the contending parties that the surgeon, who accepts the care of these cases or whose opinion is sought, obtain a complete history of the accident, a clear idea of the mechanism of production of the injury and an understanding of the underlying causes in order that he may be able to render a just opinion.

APPENDIX

Literature.—Hippocrates[37] was the first to give any information about musculotendinous displacement in luxations. In 1724 William Cowper[17] reported a dislocation in which both tendons of the biceps were rigid, interfering with extension of the elbow and in which, after manipulation, function was restored. Pouteau,[57] in 1760, doubted that tendons could be displaced. Bromfield,[10] in 1773, wrote on the technic of reduction,* Knox,[42] in 1827, was the first to notice a morbid condition of this tendon; Stanley,[67] in 1828, reported one case, found at autopsy, in which the tendon was dislocated from its groove and resting over the greater tuberosity. Monteggia,[50] in 1829, reported a recurring subluxation which could be reduced by placing the outstretched hand and arm over the shoulder of another person; John Gregory Smith,[63] in 1835, found at autopsy among other lesions of the biceps two instances of dislocated tendons in the two shoulder joints of the same subject; Adams,[1] in 1835, considered that chronic arthritis was the underlying factor of dislocation as evidenced in the case of J. G. Smith. He also believed that, in Soden's case, the dislocation was the result of arthritis rather than of trauma. John Soden,[65] in 1841, reported two cases one of which has been the subject of much discussion; Partridge,[54] in 1841, discussing Soden's case, considered it traumatic; Cooper,[16] in 1842, wrote a treatise on the subject; Hancock,[36] in 1844, gave a good clinical description of this subject; Smee,[62] in 1848, also wrote on it; Callaway,[12] in 1849, wrote a dissertation on the subject and cited a specimen (No. 55) kept in St. Bartholomew's Hospital as an example of dislocation. He discussed the difficulty of a differential diagnosis between rupture and dislocation; Parrish,[53] also in 1849, reported one case; Erichsen,[20] in 1850, wrote on the subject; Postgate[56] reported one case in 1851; Fergusson,[22] in 1853, said he had no doubt that the bicipital tendon could be displaced in dislocations as he had seen this more than once in the dissecting room; Robert W. Smith,[64] in 1853, reviewed several cases recorded in the literature as instances of partial luxation of the humerus upward with dislocation of the bicipital tendon (those of Gregory Smith, Fergusson, Smee and Hilton) and concluded that they were not of traumatic origin but the result of arthritis; Schiff[59] wrote on the subject in 1855; Hamilton[34] reported one case and Malgaigne[44] discussed the subject and especially Soden's case. He denied a traumatic luxation of the tendon unless it occurred as a complication of fracture or luxation of the shoulder; Sebregondi,[60] in 1856, reported one case; Mercer,[46] in 1859, reported one case of dislocation of the shoulder with luxation of the tendon; Hueter,[40] in 1864, gave a very clear explanation of some of the signs and symptoms in lesions of this tendon; Jarjavay,[41] in 1867, discussing several cases, thought that the signs reported were not the result of a dislocation of the tendon, but in the light of his studies, were caused by a subacromial bursitis. He further stated that a simple luxation of the tendon had never been demonstrated and, in his opinion, did not exist. Fleury,[24] in 1868, reported a case traumatic in origin, while Von Pitha[55] agreed with Jarjavay[41] and questioned the diagnosis in several of the cases reported which was "founded on symptoms referred to the neighborhood of the bicipital groove and on the associated disturbance of function." He also said that "no one had ever felt a luxated tendon on the greater tuberosity or been able to replace it." Ashurst,[5] in 1871, wrote that Canton believed the

* ". . . the cubit being bent the muscle is relaxed and while an assistant holding the lower extremity of the os brachii, moves the head thereof, sometime inward, sometime outward in the acetabulum scapulae; the operator with his fingers will easily replace it and the patient presently becomes perfectly easy."

dislocation to result from the existence of chronic rheumatic arthritis; Hood,[39] in 1871, wrote, "displacement of a tendon is certainly of more frequent occurrence than is usually supposed"; Adams,[2] in 1873, said that the luxation of the tendon was the result of arthritis and not of trauma; Green,[30] in 1877, reported a case, the result of a fall, which was reduced by a second fall; Agnew,[3] in 1878, wrote that the only unequivocal case he had seen was that of White;[70] Callender[13] mentioned one of recurring dislocation in which the tendon could not be retained in place because of fibrous tissue filling the groove and cited specimens in the London museums showing displacement of the bicipital tendon; Gerster[26] wrote that no luxation had been found, in the living subject, in its uncomplicated form and doubted its existence as such; in his opinion, when concomitant to injuries, it was a secondary pathologic phenomenon. Hamilton,[34] in 1880, cited one case of luxation; Andrews[4] a year later doubted that this tendon could dislocate, while Nancrede[51] was of the opinion that the so called luxation of the long head of the biceps was the result of chronic subdeltoid bursitis; Gross,[31] in 1882, conceded that the obscure nature of the lesion allowed it to be overlooked or mistaken for fracture, sprain or dislocation of the shoulder; Madyl,[43] also in 1882, wrote on the subject in general; Treves,[68] in 1883, recognized a traumatic dislocation of this tendon; von Volkmann[69] in the same year said that uncomplicated luxation of the tendon had not been found at autopsy. However, he mentioned a case recorded by Cloquet in which the patient could dislocate his biceps tendon at will. J. William White,[70] in 1884, reviewed the literature and discussed a case in which he believed there was a traumatic luxation of the tendon. Eastland,[19] in 1886, reported one case; Senf,[61] in 1892, wrote on the subject; Guermonprez and Ahmed Michel,[32] in 1896, reported one case concurrent with a dislocation of the shoulder; Marsh,[45] in 1896, Parkhill[52] in the following year and Robinson,[58] in 1902, wrote on the subject, each reporting one case; four years later Berne[7] reported two cases; Bossuet,[9] in 1907, reported two; Fievez,[23] in 1910, reported a case of elongation, and in the same year, Bera[6] wrote a classical thesis on the subject. Borchers, in 1914, writing on lesions of this tendon, mentioned that it could become displaced mechanically by osteophytic outgrowths of arthritic origin which fill the groove. Gurlt,[33] in 1927, found one case of tendon dislodged by the filling of the groove.

Case Reports

Case I.—A. N., male, aged 49 years, was seen first on September 22, 1925. He had hurt his right shoulder the day before, when he was standing in a crouched position, pulling a heavy steel bar which he had just driven into a board with a sledge hammer. He gave a quick pull and instantly heard a snap in the anterior portion of the top of his right shoulder followed immediately by a smarting sensation rather than severe pain. He continued working, but was unable to pull, as such effort produced pain in his shoulder. The next morning he had difficulty in raising his arm because of soreness in the upper part of his arm and his shoulder.

Examination.—September 23, 1925, no ecchymosis or tumefaction was visible. By abducting and externally rotating the arm a definite snap was felt and heard in the shoulder where the long head of the biceps emerges from the joint. This phenomenon was attributed to a recurring dislocation of the tendon of the long head of the biceps which, on rotation of the humeral head, came out of its groove and over the lesser tuberosity and then snapped back into the groove.

After a few weeks' treatment, consisting of rest and heat, the patient's symptoms subsided and he resumed his usual work, but he soon returned again complaining that his arm had grown weak and that the following movements hurt him: (1) lifting with the

arm extended; (2) putting the arm back to get into his right hip pocket; (3) rotating the arm with it extended in front; (4) pulling the arm back from forward extension. He located the pain exactly in the middle of the anterior portion of the shoulder, where the tendon of the long head of the biceps emerges from the joint.

On December 26, 1935, with arms abducted and extended, the normal convexity of the long head of the biceps was absent entirely and was seen to be flattened. The bone could be palpated between the deltoid and the belly of the biceps. On flexing the forearm only the belly of the short head was seen to contract and there were 6 cm. between the muscular belly and deltoid fold, as compared to 1¼ cm. on the uninjured side (Fig. 8).

Diagnosis.—Dislocation of the long head of the right biceps.

Operation.—January 2, 1926, under general anesthesia, a linear incision was made over the long head of the biceps muscle. The muscular portion of the long head was smaller than normal, but there was no tear in it. The tendinous portion was normal. However, the long head was elongated and could be lifted like an overstretched rubber band, as compared with the short head which had its normal contractile power. In the light of these findings it seemed best to shorten the tendon by plication, thus reducing its length about 1.5 cm. The arm was then immobilized in acute flexion in a Velpeau bandage to relieve all strain and to restore its contractility.

Result.—The patient regained complete use of his arm, and seven weeks after the operation returned to his usual work as a carpenter (Fig. 9). The muscle regained its normal size, and he was discharged as cured. Nine years later on examination I found that his arm was still normal in every respect. Even though the patient obtained such a perfect result, in a similar case I believe I should sever the tendon as high up as possible and suture it to the coracoid process and to the tendon of the short head.

Case II.—A. D., male, aged 40 years, was seen first on October 8, 1931, complaining of pain and weakness in the right shoulder and arm. On the previous day while trying to loosen some poles with a crowbar, and pulling, he suddenly felt two consecutive sharp snaps in his right shoulder and in the middle internal aspect of the right arm, as well as a dull pain in his right shoulder. He rested an hour and exercised his arm, with the hope that the pain would subside, following which he went back to his regular work of washing carpets and worked the remainder of the day, although his right shoulder pained. The pain increased gradually until the next morning he could hardly raise his elbow.

Examination.—He localized the pain by putting his finger along the tendon of the long head of the biceps which was tender to pressure, especially over the bicipital groove. Yergason's sign[27] was positive. After many painstaking examinations the diagnostic test spoken of in this paper was worked out and perfected. Roentgenologic examination was negative.

Diagnosis.—Dislocation of the tendon of the long head of the right biceps.

Treatment.—Rest with the shoulder in an abduction splint and diathermy afforded him some relief.

Result.—Operation was advised, but he preferred instead a settlement from the insurance company. He was examined recently and while the general soreness about his shoulder has improved, he still has pain when he raises his arm above his head and rotates it externally. The snap, as described in the test outlined in this paper, is still present.

Case III.—J. T., male, aged 43 years, was first seen on May 3, 1933, complaining of weakness, stiffness and a continuous dull aching in his right shoulder, more severe on movement, which prevented his raising his right arm above the level of the shoulder. On January 11, 1933, while he was pushing a hand truck, weighing about 538 pounds, over an incline, his foot slipped on the wet sidewalk and he fell foreward. He struck his right shoulder on the handle of the truck. For the rest of the day (two hours) he did light work. In spite of the use of hot compresses, the aching in his shoulder was so severe that he could not sleep. Two days after the injury he consulted a physician, who first had roentgenograms taken of his shoulder and then strapped his arm to the

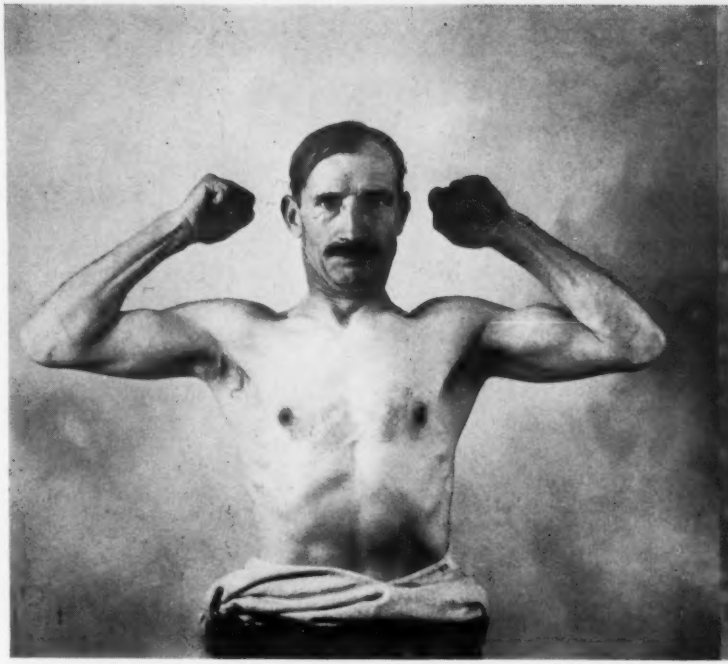

FIG. 8.—Case I. (Before operation.) Dislocation and elongation of the tendon of the long head of the right biceps. Note diminution in size, as well as the widening of space between the biceps and deltoid muscles.

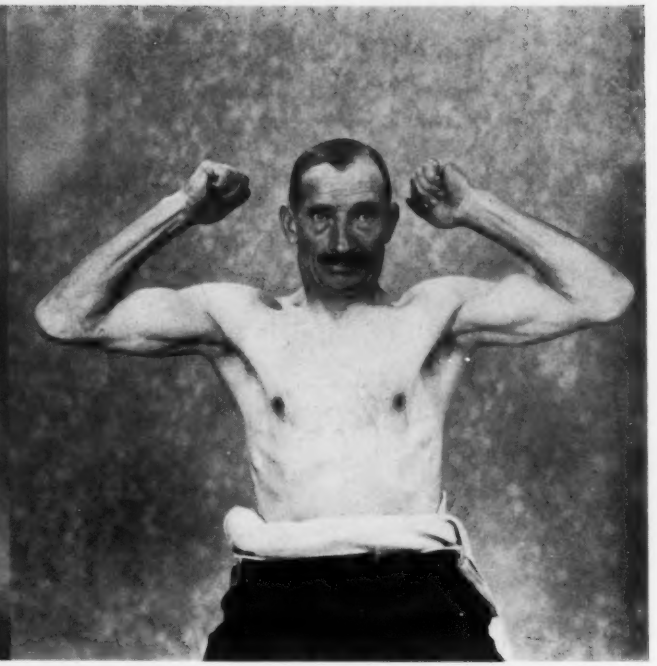

FIG. 9.—Case I. (Few weeks after operation.) Note how the muscle of the long head of the right biceps has increased in size, and how the contour of the arm is more nearly normal.

side of his chest. Since the strapping did not relieve the pain, it was removed in two days and he was given radiant heat and diathermy for a few weeks, without relief.

Examination.—General physical examination was essentially negative except for moderate pyorrhea, chronic tonsillitis and very mild chronic sinusitis and chronic prostatitis.

Right arm and shoulder.—There was a definite flattening of the right deltoid region, especially when the elbow was at the level of the shoulder. A marked depression, 10x11 cm., was evident in the substance of the deltoid muscle just below the acromion process. This area, corresponding to the level of the subdeltoid bursa, was tender to pressure, and it was at this point that he felt most of the pain on movement. There was a slight atrophy of the muscles of the scapulohumeral region. Movements were limited about 20 degrees. It was difficult to ascertain the range of motion of his right shoulder because of the pain whenever he moved the arm. On palpation he complained of tenderness in the region of the subdeltoid bursa and at the level of the intertubercular sulcus, and there was a point of tenderness which rotated with the rotation of the arm and which did not disappear when the arm was abducted. There was no definite change in the scapulohumeral rhythm nor a definite jog on abducting or adducting the arm after it had been extended overhead. At that time, examination of the long head of the biceps and of its tendon was clinically negative.

Roentgenologic examination of the right shoulder.—Outward rotation showed a small area of calcification above the greater tuberosity of the humerus, probably the result of an old hematoma.

Impression.—(1) Severe contusion of right shoulder with (2) probable partial tear of the tendon of the right supraspinatus muscle and of muscular fibers of the right deltoid muscle; (3) subdeltoid bursitis; (4) chronic tonsillitis, slight pyorrhea, and low grade sinusitis.

Treatment.—He was treated conservatively with rest of the shoulder in an abduction splint, physiotherapy, and injections of iron cacodylate intravenously which, on several occasions, I have found to be very efficacious in relieving the pain of subdeltoid bursitis.

Discussion.—The patient was kept under observation for many months, during which time he was treated conservatively and several foci of infection were given attention. The condition and the range of motion of his shoulder gradually improved. When most of the pain had subsided, his clinical picture gradually became clearer and, after painstaking and continual observation of his symptoms and signs, it became evident that he had *a partial dislocation of the long head of the biceps.* On November 6, 1933, Hueter's sign and Yergason's sign[27] were positive. The diagnostic test mentioned previously did not elicit a very definite snap, but there was more severe pain when all these three signs were tested without holding back the muscle belly or the tendon of the biceps, pushing it outward and posteriorly, or when the arm was lowered in internal rotation. This maneuver evidently held back into the groove the tendon of the long head so it reflected itself over the slope of the lesser tuberosity and not over the sling formed by the tearing of the capsule which occurred at the time of his injury when he had abducted his right arm violently and brought it in overhead extension and external rotation. He had, therefore, put indirectly a great strain on the attachment of the articular capsule in the region proximal to the lesser tuberosity which forms the roof of the osteofibrous tunnel of the bicipital groove.

Progress.—After a year and a half of conservative treatment, his range of motion was almost normal and the weakness and pain in his arm were greatly relieved. He was discharged as being able to resume work.

Case IV.—R. G. H., male, aged 50 years, dentist, was seen first on December 9, 1933, complaining of neuritis in his left shoulder and arm. About seven years before, he began to have a dull ache in his left shoulder which radiated down his arm and which he attributed to muscular strain. This condition had become worse slowly and progressively until, at the time when I first saw him, he was even disturbed at night. In fact, he

had to sleep on his back with his left arm abducted to 90 degrees, the elbow flexed at a right angle and the hand at the level of the head. Recently he had not been able to bring his arm above a horizontal plane unless he twisted his forearm, first supinating and abducting it, then pronating it while he gradually lifted it with the other hand. The pain ceased after he abducted his arm to about 80 degrees. He also had pain radiating down the biceps when he leaned back against a chair.

Examination.—A creaking sound could be heard in both shoulders on the abduction of both arms. There was pain on pressure at the lower end of the left bicipital groove. Hueter's and Yergason's signs were negative. He could abduct his left arm to 75 or 80 degrees without pain, then he halted because pain was elicited in the shoulder. To obtain overhead extension, he lifted his left arm in medial rotation with elbow slightly flexed until he reached about 45 degrees abduction. Then he had to rotate the arm externally, after which with a jerk and twinge of pain he was able to accomplish overhead extension.

Abduction and elevation of the left arm were not so painful when the biceps muscle was held and pushed outward, as if to hold the tendon back in the groove.

Progress.—Operation was declined. His condition remained almost stationary and about a year after he was seen last, he had to give up his work on account of pain in the shoulder.

Case V.—V. M., male, aged 52 years, on March 24, 1933, fell, striking on his right shoulder. He tried to check his fall with hand and wrist against the ground by strongly rotating the right arm externally. The instant he struck the ground he felt a snapping sensation "like a string breaking." Inasmuch as he felt as if the shoulder were out of joint, other workmen pulled downward on the arm with counter pressure in the axilla, and the shoulder seemed to snap back into place. He felt better after this but on account of soreness in his shoulder and arm, was unable to work. He saw a physician and was advised to keep his arm at his side. He first began to use his arm in about two weeks. Finally he felt well enough to work four days during the first week of June, but a return of pain stopped him. He worked three days during the last week of June. He suffered no pain with his arm across his chest, but attempts to use the arm caused pain at the top of the shoulder; a fairly regular snapping was heard and felt deep in the upper front part of the joint and over the front of the humerus at or just below the insertion of the pectoralis major muscle. His condition did not improve. The patient gave a history of never having had arthritis, lumbago, neuritis or sciatica.

Examination.—July 22, 1933, the right shoulder snapped audibly when abducted and rotated. This snapping, I thought, was caused by the tendon of the long head of the biceps which seemed to be displaced forward, lying just in front of the tip of the coracoid, and which snapped back and forth at the level of the tip of the coracoid on abduction and particularly rotary movements in from 60 to 80 degrees abduction. He felt pain over the tip of the coracoid when the snapping occurred, and this area was distinctly tender. There was a slight tenderness also over the region of the subdeltoid bursa. There was very little atrophy. Normal range of movement was present.

Roentgenologic Examination.—Roentgenograms (stereoscopic, internally rotated and single, externally rotated) taken July 22, 1933, showed a small calcified mass in the region of the subdeltoid bursa. There was also a curved narrow line of increasing density in the region of the bicipital groove which was interpreted as calcification where the periosteum had been torn when the tendon of the long head of the biceps was forced from its groove. On the inferior surface of the clavicle a well-developed bony prominence appeared where the coracoclavicular ligaments attach, but the normal relations of clavicle and scapula excluded injury as a cause, and the pattern of the bone seemed normal and did not suggest an arthritic etiology.

Impression.—A forced active movement of external rotation and supination against resistance has caused the tendon of the long head of the biceps to tear loose from its groove. It now lies just anterior to the coracoid process and certain movements cause it

to snap back and forth at the level of the tip of the coracoid, causing pain and chronic irritation.

Operation.—August 5, 1933, a six-inch incision was made along the anterior margin of the deltoid muscle. The deltoid was separated from the pectoralis major by sharp dissection and retracted laterally and upward. The tendon of the long head of the biceps was felt lying medial to its normal location in the bicipital groove. The transverse humeral ligament was found detached from the lesser tuberosity of the humerus for a distance of 1 to 1½ inches. It was cut to expose the bicipital groove. The biceps tendon lay outside the groove at this point, having slipped across the denuded lesser tuberosity. The point of the lesser tuberosity was sharp and prominent, and movements of the arm caused the tendon to snap over it. This was evidently the chief cause of the painful snapping at examination. The nature and extent of the damage made repair of the transverse humeral ligament impossible. Repair by fascia lata would have required bone work at the subscapularis insertion, which would have been painful for some time, with slow convalescence.

The cut biceps tendon was freed of areolar tissue and split, each half being looped through the bone tunnel and sutured to the outer half in the groove. The transverse humeral ligament and periosteum were closed over and sutured to the tendon in the bicipital groove, with interrupted No. 0 chromic catgut. The deltoid was replaced and lightly sutured with No. 00 plain catgut. The skin was closed with interrupted black silk without drainage. A starch bandage and yuca board were applied with the elbow flexed and the arm held in the Velpeau position. Convalescence was uneventful. He returned to light work much improved on November 28, 1933, and since has resumed his regular heavy work.

Case VI.*—J. T., male, aged 49 years. On December 22, 1933, a piece of equipment, weighing 200 or 300 pounds, toppled two or three feet and struck the front of his left shoulder, his arm being forced into external rotation in a position of 60 degrees abduction. The weight pinned him against the flat surface on the wall behind. As his shoulder was painful he did little work for the rest of the day. A swelling the size of a walnut appeared on the front of the shoulder, but gradually subsided. He complained of pain over the front of the shoulder and a cracking sensation on raising the arm from the side. Any use of the arm caused soreness which lasted for some time. At first he had pain in the shoulder at night, but it became less. He could do straight lifting with arms dependent without pain, so long as he did not abduct. He had no previous injuries, arthritis, lumbago or neuritis, and his general health was good.

Examination.—Examination of the left shoulder on January 23, 1934, revealed a clicking and grating on motion. The biceps tendon clicked. The biceps (long head) did not contract firmly unless he made a special effort. There was some crepitation and pain in the shoulder on abduction of the arm. Range was not restricted. There was tenderness and a click on rotation in the region of the bicipital groove, especially with the biceps taut. Roentgenologic examination was negative.

Impression.—The tendon of the long head of the biceps slips out of the groove. Thickened soft parts crepitate and pinch slightly in passing under the acromion.

Operation.—January 26, 1934, the tendon of the long head of the biceps was exposed. It had torn the transverse humeral ligament and lay about one inch anteriorly to its normal position. The groove which it normally occupied was so filled with lacerated soft tissue and granulations that the tendon could not be replaced in its normal position. The tendon itself was frayed along one margin.

The shoulder joint was opened and the tendon cut free from its attachment to the scapula. The tendon was denuded of areolar tissue and split longitudinally. The bicipital groove was denuded of soft parts and a small tunnel was made through the bone. Through this tunnel one-half of the split tendon was looped, and brought back and sutured to the

*I am indebted to Dr. Edward C. Bull for the report of both Cases V and VI.

other half. The reflexed periosteum and soft parts were sutured over the transplanted tendon. The incision in the shoulder joint was sutured and the deltoid muscle was brought back to its normal position and likewise sutured.

Progress.—His shoulder improved very definitely, and his arm was freer and stronger, but as he continued to have pain on abduction and external rotation, it was decided to do an exploratory operation.

Operation.—February 2, 1935, it was found that the greater tuberosity was striking the acromion as it moved beneath this bone in the act of abduction.

Progress.—Since the second operation he has been even more relieved and is still improving.

I wish to express my appreciation to my associate, Dr. Piero Albi, for his splendid assistance in the preparation of this paper, for reviewing much of the foreign literature and for compiling the complete bibliography.

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LIPOMA OF THE EXTREMITIES

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DURING the course of a general study on the clinical characteristics of soft tissue tumors of the extremities, it has become increasingly apparent that the benign lipoma plays an unappreciated though extremely important rôle. Lipoma is the diagnosis in over 50 per cent of these neoplasms, and its very frequency, disarming to unguarded observation, makes it the most common diagnostic error to be found in any series of such cases. The true importance of this error lies in the fact that about one-third of the soft tissue tumors occurring on the extremities are malignant or potentially so, and a false diagnosis of lipoma too often leads to inadequate therapy. It is common knowledge that surgical trauma, improperly or incompletely administered, especially to a tumor of the sarcoma group, is one of the activating forces of primarily low grade malignancy. Hence the casual enucleation of a supposedly benign lipoma in a patient subsequently lost to the clinic before the pathologist's report becomes available, or reassured without histologic confirmation of the diagnosis, may cause an avoidable loss of life or limb.

It has been shown elsewhere that the common soft tissue tumors of the extremities do not appear at random, but present clinical characteristics which suggest, if not determine, their diagnosis. We know of no such study concerning the lipomata. One hundred sixty-two lipomata, representing 54 per cent of 300 soft tissue tumors of the extremities form the material upon which this report is based. It portrays the clinical history of these neoplasms, their diagnostic criteria, and indicates the proper considerations for therapy.

Surgical Pathology.—Lipomata are tumors composed of neoplastic fat cells growing in a more or less dense fibrous stroma. The density of the fibrous stroma varies with the location of the tumor, and, in a true lipoma, is of no pathologic significance. However, this variation in the density of the stroma has led to unnecessary and confusing subclassification such as fibrolipoma or lipofibroma. These terms should be used only in those rare cases where actually neoplastic fibrous tissue is present along with lipomatous growth. Otherwise only the term lipoma is justified. Grossly these tumors appear as a mass of fat which may or may not be encapsulated. A lattice work of fibrous strands can be seen within the mass. The fatty tissue appears lobulated, and on careful inspection a vascular tree can be seen with minute vessels feeding each lobule. Histologically when stained with hematoxylin and eosin, the typical "engagement ring" cell is observed, with a single nucleus placed peripherally in a transparent protoplasm surrounded by a well defined

cell wall. The fibrous strands of the stroma appear as simple connective tissue within which are found the minute blood vessels and nerve filaments.

Etiology.—Trauma while occasionally mentioned in the histories of these cases as preceding the onset of tumor cannot be seriously considered as an etiologic factor. The favorite sites of election, and the frequent occurrence of these tumors without any appreciable trauma, eliminate its probability if not its possibility.

Location.—About one-half of these tumors occurred in the upper extremities, and one-half in the lower. In the upper extremity, 55 per cent occurred in the region of the deltoid muscle, and 21 per cent at the axilla. Together, 76 per cent of lipomata of the upper extremities were found about the shoulder joint. The remainder appeared equally divided along the extremity, but were usually found on the flexor surfaces. In the lower extremities, the distribution was homologous. Eighty-three per cent appeared either on the buttocks or on the upper half of the thigh. (This is in distinct contrast to fibrosarcomata, which occur predominantly at the lower half of the thigh.) The predilection of lipomata for areas of greatest fatty tissue deposit is obvious.

In 20 of our cases (12 per cent), the tumors were multple, ranging from two to six in number. Although there was a wide distribution of the multiple tumors, frequently involving not only the extremities, but also the trunk, in many instances the tumors were found concentrated on the forearm of a single limb. The suggestion has been made that multiple lipomata occurring on a single limb may be related to a nerve distribution, therefore they may have a neurogenic relationship. In our group the distribution in the forearm cases was anatomically so diverse that no single nerve tract could be held responsible. Cases of generalized lipomatosis were not included in this study, since they represented concepts extraneous to the present problem.

Lipomata of the extremities are almost always found in the subcutaneous tissues. However, they may appear in the muscles, in the intermuscular spaces, or even in relation to bone. Kuttner and Landois, in 1913, gathered 27 cases from the literature in which lipomata were situated within muscle tissue. Mullen, in 1932, noted that intramuscular, or, as he termed them, "intrafascicular" lipomata were most commonly found within the triceps cruralis and the biceps brachialis. None of our cases was intramuscular.

Behrend described a series of lipomata found within the intermuscular spaces. Three such (1.7 per cent) appeared in our list. Intra-articular lipomata, derived from the fat pads of the large joint, or the adipose tissue of the subsynovial layers, while not common, are by no means rare; especially within the knee joint. These have been described by many authors. They grow into the joint space, sometimes to a large size, and often resemble a localized synovial hypertrophy. However, on arthrotomy, the true lipoma is found to be a demarcated mass, frequently pedunculated, in the midst of normal synovia, while synovial hypertrophy, always secondary to synovitis,

is more diffuse, congested and is apt to show areas of mucoid degeneration on its surface.

Lipomata of bone are rare but do occur within the bone marrow. Ewing describes a case occurring within the marrow of the fibula of a young girl. In such cases there are said to be no signs or symptoms either clinically or roentgenologically. Their presence is usually disclosed as an incidental finding. However, another form of lipoma involving bone, equally as rare, is of greater consequence, since it closely simulates a bone tumor. This is the so called periosteal lipoma. Two such cases were described by Bartlett, and Geschichter and Copeland have described another. This lipoma becomes attached to periosteum, probably as part of its fibrous capsule. As it grows it presses against the cortex of the bone. Two reactions have been described. In one the bone appears to be bent by the pressure of the growing tumor, in the other, a depression is made on the cortex which in the roentgenogram gives the appearance of erosion and suggests osteogenic sarcoma. However, there is no periosteal reaction visible, no changes in skin overlying the tumor, and at operation, a flattened depression is seen without any invasion of bone tissue. The cortical line, though depressed, remains intact. One such case occurred in the present series, in which the lower end of the fibula in a young woman was involved.

Age of Onset.—Lipomata may appear at any age but are preponderantly tumors of middle life. Seventy-five per cent of the cases appeared between the ages of 20 and 50, equally divided among the three decades. In two of the cases the tumors were said to have been congenital, although no medical evidence proved the statement. At least they did appear in infancy.

Duration.—Figures concerning duration in these benign tumors are meaningless. They run from six months to 30 years. The duration of tumor depended upon many irrelevant factors, among which were cosmetic, fear of "cancerous change," inflammation in or about the tumor, local infection or ulceration, and in some cases the insistence of medical advice in patients appearing for other causes. Lipomata of the extremities have lasted a lifetime, remaining stationary after reaching a given size which may be that of a grape or a grapefruit.

Pain.—Lipomata are not *per se* painful tumors. However, it must be emphasized that this is not an important differential characteristic since pain is rarely an important presenting symptom in certain of the other common soft tissue tumors of the extremities. When pain is present in lipomata of the extremities it is due either to anatomic encroachment on neighboring tissues subject to painful stimuli, such as nerves, muscles or periosteum; or due to inflammation, usually traumatic, of the tumor itself. One case in this series was admitted because of persistent pain, with edematous swelling and cyanosis of an upper extremity. This was caused by an axillary lipoma obstructing the brachial vessels. Occasionally one finds a lipoma producing pain radiating along a nerve, suggesting the diagnosis of Schwannoma or neurofibrosarcoma. This symptom has been shown not to be pathognomonic of

Schwannoma, although of course strongly suggestive of it, since any tumor surrounding and pressing on a nerve may cause such pain.

Physical Characteristics.—These neoplasms are usually soft, but their consistency varies with the density of the fibrous tissue stroma described above. However, they are not as firm to touch as are the true fibrous tumors. Occasionally their softness may be extreme and suggest fluctuation. Lipomata of the extremities vary in size from that of a grape to a grapefruit. Rarely they attain even larger proportions. They are mobile within the subcutaneous tissues, but when attached to deeper structures they may be sessile, pedunculated, or diffuse. The last form is characteristic of intramuscular lipomata. They are never tender unless inflamed. Soft tissue sarcomata, on the other hand, are frequently tender. Subcutaneous lipomata usually appear well demarcated on palpation. Soft-tissue sarcomata are usually more diffuse. The skin and vessels overlying lipomata show no changes, even in the presence of a fairly large mass, whereas engorgement of the cutaneous vessels overlying sarcomata, while not always perceptible, when present, differentiates the latter. Lipomata may or may not be encapsulated.

Malignancy.—Lipomata are benign tumors. However, rare reports of malignant change must be noted. Ewing quotes Benel and Delachanel in describing a case in which the authors followed the myxomatous and sarcomatous transformation of a lipoma involving the sciatic nerve sheath which eventually produced lipomatous and sarcomatous metastases in lymph nodes and lungs. Stewart reported three cases which he classified as liposarcoma of bone, but in his report he indicated the very reasonable doubt which the diagnosis entailed. The diagnosis of liposarcoma must be made with a full understanding of its essential histogenesis. Fat cells originate from a connective tissue anlage in which the embryologic elements carry the potential factors for differentiation into fat cells. Liposarcoma can arise, not from mature fat cells, but from their embryologic, more fibrous, forms. Their ability to create adipose tissue in a metastatic focus is comprehensible only by this assumption.

In our series there were no tumors which could be classified as liposarcoma, although several in which lipomatous tissue was in close proximity to areas of sarcoma were suggestive. Less than 1 per cent of the cases were recurrent and these were always benign tumors, suggesting the great probability of incomplete primary removal. Multiple tumors may grow independently in different parts of the extremities with no apparent direct relationship to each other. However, some individuals act as though they possessed a generalized susceptibility to lipomata because of the numbers of such tumors they present.

Treatment.—Lipoma occurring in the subcutaneous tissues should be excised, if for no other reason than to confirm the diagnosis. Besides this, however, such a tumor visible or palpable on the body surface is invariably tampered with by the patient. Hence, infections in younger patients, and ulcerations in older ones are by no means rare. In the so called periosteal

lipoma, excision is imperative. The question of diagnosis is more essential, and the possibility of local skeletal deformity is always present. Intramuscular and intermuscular lipomata present individual problems—after diagnosis is confirmed, best by punch or incision biopsy. In these cases the probability of diagnostic error is greatest because of their clinical similarity to fibrosarcomata. When the presence of benign lipoma is established, the advantage of excision must be weighed against the disadvantage of postoperative dysfunction. If the tumor does not interfere with muscle function, or with the circulation of the extremity, it is better left alone. If it interferes sufficiently, wide excision including involved muscle tissue should be performed. Radiation has not as yet been proven effective for these neoplasms.

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BRIEF COMMUNICATIONS AND CASE REPORTS

MESENTERIC APOPLEXY *

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Case Report.—A female, aged 80, while sitting quietly at home was seized, on the evening of April 25, 1935, with acute, cramp-like, generalized abdominal pain. She went to the toilet immediately but passed neither feces nor gas, then, feeling very weak, she fainted. When seen a few moments later she had recovered consciousness, but was in a condition of collapse with pallor, cyanosis, and rapid, thready pulse, but no fever. Her abdomen was rigid and exceedingly tender throughout.

With the exception of an operation for acute suppurative appendicitis 20 years before, the patient had always been in good health. Convalescence was complicated by the presence of numerous peritoneal adhesions and required a long period of drainage.

For several years the patient had had occasional appearances of large subcutaneous ecchymotic spots, especially about the hands and fingers, which apparently represented the rupture of small superficial vessels, and of recent years she has shown some evidence of advancing arteriosclerosis and cardiac weakness. Blood pressure has ranged from 160/110 to 200/120.

The patient was put to bed following her seizure, and during the succeeding 24 hours, while her general condition improved, the abdomen remained very tender, somewhat rigid, and became greatly distended. There was no spontaneous passage of either feces or gas, although milk and molasses enemata and colonic irrigations succeeded in removing a little gas with a portion of inspissated feces. It was felt that the patient was suffering from acute intestinal obstruction, presumably due to the effect of her old operation and its concomitant adhesions. She was removed to the hospital the following evening. A flat film of the abdomen indicated fluid levels and was typical of acute obstruction.

Immediate operation was performed. A long right rectus incision was made, extending from above the umbilicus almost to the pubis. Markedly distended coils of intestine were immediately extruded and the excessive peritoneal fluid was decidedly blood stained. An attempt at exploration encountered, everywhere, numerous firm bands of adhesions which practically precluded satisfactory mobilization of the intestine. The blood in the peritoneal fluid seemed to be coming from the right upper quadrant. Exploration of this area revealed a mass which, following separation and division of adhesions, was found to consist of a massive hemorrhage between the leaves of the mesentery of the colon in the region of the hepatic flexure. The colon in this area appeared to be blackened and was markedly distended. It was apparent that spontaneous rupture of the colica dextra had occurred producing an hematoma and seriously compromising the blood supply to about six or eight inches of the hepatic flexure. The effect of this presumably was to produce evidence of intestinal obstruction, probably further enhanced by the presence of dense adhesions especially in this area. The leaves of the mesentery were separated and the clot removed. The original area of hemorrhage was not discovered. Several bleeding points in the mesenteric vessels were controlled.

* Presented before the New York Surgical Society, October 23, 1935.

Closer investigation of the segment of blackened gut showed that some of this appearance was due to the formation of a clot about the intestine which, when cleared away, showed the gut wall to be purplish but still viable.

Following the severance of constricting bands in the area, a cecostomy was performed at the lower angle of the wound, the peritoneal cavity evacuated of fluid and blood, and the abdomen closed.

The patient's recovery from the operation was slow and rather stormy. The cecostomy performed satisfactorily, the Pezzer catheter being removed on the eighth postoperative day. The temperature subsided to normal on the eleventh day and the patient was discharged on the thirty-first postoperative day. By this time, bowel movements were occurring normally and the discharge from the cecostomy wound was diminishing. This eventually closed spontaneously. Normal function of the bowel was satisfactorily established within two months after her discharge. The only complication in her subsequent course was a rather severe attack of herpes.

The accident from which this lady suffered is a clinical rarity. Hitherto but four cases of mesenteric apoplexy have been reported in medical literature.[1, 2, 3, 4] In all four, rupture occurred in branches of the celiac axis. The vessels involved were the gastroduodenal, left gastro-epiploic, left gastric and right gastric. This is the only case so far reported of spontaneous rupture of an artery in the colic mesentery. The patient is the oldest to survive this accident. The ages of those previously reported were 27, 54, 57 and 60. All but the 27 year old patient suffered, as did the present patient, from definite arteriosclerotic changes associated with hypertension. In no case was the diagnosis made before operation.

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Discussion.—Dr. F. W. Bancroft (New York) thought that frequently cases thought to be occlusion from within the vein were due to pressure from without. When an abdomen is opened, where there has previously been an abdominal incision and where there are intestinal adhesions, the pathology may not be recognized through a small abdominal incision. In freeing the adhesions a volvulus or a band may be separated which may have been the cause of presumed gangrene, and the occlusion of the vessel may be due to pressure from without, and not be a primary lesion within the vascular lumen. Furthermore, what is frequently considered to be a gangrene is in reality venous hyperemia. For instance, in gallbladder operations the impression is often created that there is gangrene of the gallbladder, whereas on microscopic examination of the gallbladder wall one is surprised to see marked engorgement of the vessels and hemorrhage into the tissues—and not, at that particular time, gangrene, but, instead, there was venous occlusion with arterial blood pumped in during the early process, with extravasation of blood into the tissues. When the pressure becomes high enough for arterial stasis,

then thrombosis occurs and gangrene results. Many cases considered to be beginning gangrene of the bowel are in reality probably instances of venous hyperemia.

In the case just reported, the blood clot was evacuated and the condition seems really to have been an apoplexy. However, it is conceivable that in a lesser stage of this particular type of extravasation of blood between the leaves of the mesentery there might have been a venous occlusion due either to pressure from without or to thrombosis from within, with secondary weeping eventually resulting in the formation of an hematoma.

Dr. Howard Lilienthal (New York) said that, while not doubting it, diagnosis must have been difficult even after free exposure was obtained. The sudden onset was suggestive, but it was rather remarkable that there was not a continued free, alarming hemorrhage, considering that the patient was operated upon so soon after the accident.

Dr. Seward Erdman (New York) had never understood quite how there could be enough pressure from hemorrhage to interfere with the viability of the part. How could the same pump mechanism keep pumping blood into an hematoma with sufficient force really to devitalize tissues, despite the fact that blood is imprisoned between different layers, and how could the arterial blood pressure be any higher at one end of the circuit than at the other?

Dr. Cutler said that he did not wish it to be understood that there was actual devitalization of the intestine, although this appeared to be so at first. That there should have been a certain amount of cyanosis of that loop of gut —which appeared to be the case—might readily be explained on the basis of the mass of arterial origin between the leaves of the mesentery, pressing upon and interfering with venous return. Had the mass not been quite so large, it might be assumed that there was sufficient circulation from the ends of the affected gut to overcome the discoloration, but there was an area of intestine fully eight inches in length which was definitely bluish, almost purplish, in color. Another factor may have been the nearby adhesions. The entire intestine was distended and there were numerous adhesions. It may be that some interference with the vascularity was produced by those two combined factors. The condition could not readily be explained on any other basis than mesenteric apoplexy, taking into account the sudden spontaneous onset and the development of massive hemorrhage within the leaves of the mesentery. Although the hemorrhage was somewhat controlled by its own pressure, it continued when the abdomen was opened so that ligation of bleeding arterial vessels was necessary. It was impossible, however, to identify the single large vessel from which the bleeding originally came. It was the continuous bleeding, slow and slight though it was, coming down from that part of the abdomen, that led to exploration of the area.

GASTROCHOLECYSTIC FISTULA *

VOMITING AND PASSAGE OF GALLSTONES PER RECTUM

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Case Report.—A female, aged 33, was admitted to Beekman Street Hospital July 25, 1935, with a history of right upper abdominal discomfort for two weeks. For the previous three days the pain had become progressively more severe and was associated

* Presented before the New York Surgical Society, October 9, 1935.

with repeated attacks of vomiting, during one of which she claims she vomited six or seven dark stones, each the size of a coffee bean or larger. Except for a three months' period of postprandial discomfort two years ago, eventually controlled by a careful Sippy regimen and bland diet, she had remained free from complaints until the present trouble.

Examination revealed a moderately obese Negress suffering from severe upper abdominal pain with a spastic right upper quadrant and distinct tenderness over the gallbladder region. Her temperature was 100° F.; white blood cells 12,600; P.N.L., 85 per cent. Her condition was considered to be one of cholelithiasis and acute cholecystitis. For the first 48 hours there was constant, severe, uncontrollable right upper quadrant colic associated with repeated vomiting. On the third day her symptoms suddenly ceased, and several hours later, in the course of a rectal examination, a gallstone 2.5 cm. in diameter was removed. The history of vomiting stones as well as the passing of a stone by rectum made the diagnosis of a fistulous communication between the gallbladder and gastro-intestinal tract evident. A dye test failed to reveal the gallbladder.

Exploration July 31, 1935, revealed a moderately thickened gallbladder containing no stones and with no evidence of recent intrinsic or extrinsic inflammation. The inner aspect of the neck of the gallbladder just distal to the cystic duct was intimately fused for a distance of 2 cm. to the superior and posterior aspect of the pyloric end of the stomach. The gallbladder was carefully separated from above downward until this attachment was reached, when it was opened a fistulous communication was exposed through which a probe was readily passed into the stomach. The cystic duct was occluded. The gallbladder was then cut away from the stomach, leaving a rather rigid opening 2 cm. in diameter. This was closed with difficulty by an inner mattress suture of chromic gut and an outer one of linen. The gallbladder was then removed. Some troublesome bleeding occurred in the region of the right hepatic duct which was controlled by three long artery clamps. These were left in situ because of the fear of compromising the duct in attempting to ligate the bleeding vessels. Gauze packing was placed around the clamps and a tube inserted into Morrison's pouch. On the fifth postoperative day, clamps and packing were removed, following which a thin, brownish, colon-smelling discharge appeared, suggesting a fecal leak. This continued for seven days, becoming thinner and less odorous, though more profuse. Methylene blue given by mouth appeared quite promptly in the wound, indicating that the suture closure had given way. Because of a conceivable duodenal leak the skin was protected by a copper powder and bronzing liquid, and suction was applied to the wound. There was no tendency to erosion of the skin. The patient's condition was improved rather than impaired. The discharge was acid; no pancreatic ferments were found. The fistula was evidently of gastric origin. The drainage became progressively less after the tenth postoperative day, the wound healed rapidly, and the patient was discharged on the twenty-third day after operation.

Although spontaneous internal cholecystoduodenal and cholecystocolic fistulae are not infrequently seen, cholecystogastric fistulae are apparently quite rare. Judd and Burden, in 1925, reported 153 cases of internal biliary fistulae operated upon at the Mayo Clinic, of which 117 communicated with the duodenum, four with the duodenum and colon, 26 with the colon, and only six with the stomach. Isolated cases have been reported by Ochsner, Snively, and Ranken. The vomiting of gallstones is apparently very unusual, and although suggestive of a gastric communication, is not necessarily so, for since bile is frequently regurgitated into the stomach it is conceivable that small gallstones could also be. It is interesting, that the original symptoms, two years prior to the admission of this patient, were distinctly of the peptic ulcer

type, suggesting the period when the fistulous communication was most probably being established.

DISCUSSION.—DR. RALPH COLP (New York) said that with the present early diagnosis of—and operation for—gallbladder disease these cases are rather infrequent. Doctor Mage's case was unique in that the diagnosis was made preoperatively because of the vomiting of gallstones and the passage of one by rectum. Another interesting feature is the fact that the patient complained of severe colicky pains and for four days vomited almost uncontrollably. Suddenly, with the coincidental passage of a gallstone by rectum, the vomiting ceased. It is barely possible, inasmuch as the findings at operation showed no acute pathology, that the acute symptoms were due to the presence of a low grade, intermittent intestinal obstruction caused by the stone in its passtage through the small intestine. In the past few years at Mt. Sinai Hospital there have been five cases of intestinal obstruction caused by gallstones. In some, they were ordinary large stones; in other instances, the caluli had had an accretion of fecal material. In one of these cases, upon whom Doctor Klingenstein operated, it was possible to make a preoperative diagnosis of intestinal obstruction due to gallstone. The only measure taken in these cases was to relieve the intestinal obstruction by removing the stone. No further operation was performed for the fistula, which certainly must have been present, because the patients did not complain of any symptoms referable to the upper abdomen. In order to have a fistula, there must be obstruction to the cystic duct. Once perforation has occurred into an adjoining viscus the chances are probable that with evacuation and continuous drainage of the gallbladder, subsequent operation will be unnecessary.

LEIOMYOSARCOMA OF THE JEJUNUM *

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STATISTICS dealing with the frequency of occurrence of tumors in the small intestine exhibit a wide variation. Perhaps the most comprehensive study published in recent years is that of Raiford,[1] who collected a series of 986 tumors of the gastro-intestinal tract. Of these, 88, approximately 9 per cent, were in the small intestine, and 14 in the jejunum. None of the latter was a leiomyosarcoma, although there was one myoma and one spindle cell sarcoma. Joyce[2] cites among nine cases of small intestine tumors one leiomyoma of the jejunum which closely resembles the case about to be reported, but which was benign. Prey, Foster, and Dennis[3] collected from the literature 61 cases of primary sarcoma of the duodenum and added a personal case. Forty-eight of these had an histologic classification. The great majority were lymphoblastoma, only four having been myosarcoma. Cabot,[4] Cattell and Woodbridge,[5] Bagozzi[6] and others have reported single cases in recent years. Corner and Fairbanks[7] state that the ratio of myosarcoma to other types in the small intestine is 2 to 63, while Speese[8] places it at 1 to 96. Anderson and Doob[9] found only 18 cases to have been reported in the literature from

* Read before the Philadelphia Academy of Surgery, May 13, 1935.

1875 to 1933, inclusive. In 13 of these in which the site was mentioned, ten were in the jejunum, one in the ileum and two in the duodenum. Metastases were reported in only four of this series. The incidence was greatest between the thirtieth and fiftieth years.

The case here described agrees with the majority of those encountered in that the cardinal symptom was bleeding from the bowel, that roentgenologic examination was of no help in the diagnosis, and that pain was a late manifestation. Obstruction appears to occur very infrequently. Perforation has been observed in several cases. The prognosis is guardedly good.

Case Report.—R. W., aged 20, a white, unmarried female, was admitted September 5, 1933, to the medical division of the Mt. Sinai Hospital with a diagnosis of secondary anemia after a hemorrhage from the bowel. After a short period of treatment she was transferred to a convalescent home. While there she began to experience pain in the left lower quadrant of the abdomen. She returned to the hospital on November 7, 1933. A sense of resistance was found in the area corresponding to that in which the pain was felt. This was considered to be due to a spastic colon or to a ptosed kidney. The usual examinations, including cystoscopy and barium enema were negative, except for occult blood in the stools and a ptosed colon. No tubercle bacilli were found in the feces. The patient was discharged improved after three weeks. She returned to the convalescent home, where she felt perfectly well until December 10, 1933, when she awakened with a throbbing sensation in the head. This passed off in a few hours but recurred next day. Her stools had been very dark for several days. She was put to bed and given a restricted diet. The color of her stools returned to normal. When, however, she resumed activity and a more liberal diet, her stools again became tarry, and her hemoglobin was found to be 40 per cent. She once more entered the hospital on December 17, 1933.

At this time general examination was again substantially negative. Her stools constantly contained occult blood, usually rated 4 plus, but occasionally declining to a trace. Gastro-intestinal roentgenograms were normal except for colonic ptosis. Proctoscopy and sigmoidoscopy were negative. With the aid of several transfusions her blood picture improved only slightly.

After nearly two months of treatment on the medical division, the patient again began to have pain in the left lower quadrant. The temperature became elevated, there was leukocytosis and a tender circumscribed mass became palpable. She was transferred to the surgical service of Dr. E. L. Eliason, and her abdomen opened on February 12, 1934, through a muscle-splitting incision over the mass. The latter was entered and found to contain a large quantity of pus with the odor characteristic of B. coli. The abscess was drained. No effort at exploration was made. The patient continued to pass blood by bowel, and was given transfusions from time to time. Pus drained from the abdominal incision continually. She frequently complained of severe colicky pains, but they were inconstant in location and irregular in occurrence. Although she improved somewhat, her stools were never free from considerable quantities of blood and it was finally decided to operate again.

The abdomen was opened, April 28, 1934, through a median incision. A mass was found consisting of two loops of jejunum and one of sigmoid bound together, with a tumor in one of the jejunal loops. The latter was in communication with a sinus which extended to the exterior through the first incision. The tumor was an irregular, nodular mass with an ulceration of the mucosa, and was evidently the source of the bleeding. The loops were dissected free, the tumor-bearing portion of the jejunum resected and a lateral anastomosis performed. Convalescence was relatively uneventful and the patient was discharged with both wounds healed some four weeks later. She has remained well. Bowels move frequently without laxatives. A gastro-intestinal roentgenologic study

made February 1, 1935, showed no abnormalities. Stools are free from blood and her blood count has returned to normal.

The patient died about September 1, 1935, of a recurrence of the original growth.

Pathologic Report by Dr. D. R. Meranze.—Macroscopic.—The specimen consists of a portion of the bowel and measures 25 cm. in length. Occupying one end of the bowel is a large tumor mass measuring 8 by 9 cm. which apparently springs from the entire circumference of the bowel and projecting into the lumen practically occludes it. The tumor mass is composed of a yellowish-white, firm and friable tissue, which has taken on a grossly ruffled appearance. The ruffled character is also evident in the two secondary tumor growths arising at the periphery of the original growth. The neoplastic involvement has in some regions extended to the serosa and produced nodular projections through it. Some portions of the tumor mass are markedly hemorrhagic. Other areas have a yellowish-white translucent aspect. About one-half of the upper portion of the tumor has ulcerated away. The lumen of the bowel below the tumor is filled with dark clotted blood. What is taken to be a node on the serosa is apparently infiltrated with the neoplastic tissue. In one region the tumor has apparently stimulated a marked fibrous reaction.

Microscopic.—The mucosa shows no primary neoplastic process. Some portions of

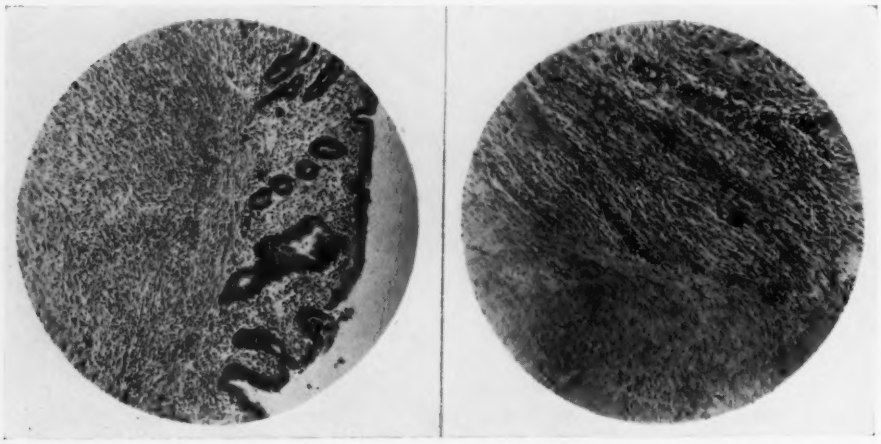

FIG. 1.—Low magnification. FIG. 2.—High magnification.
Photomicrographs showing infiltrating character of growth.

it have undergone necrosis. A neoplastic process occupies the site of the muscle coats of the jejunum, and apparently is primary in this region. It consists of a spindle type cell, whose nuclei show considerable polymorphism and many mitoses. The process has infiltrated the submucosa and mucosa, replacing the layers and causing the necrosis described above. It has also penetrated the serosa and periserosal tissue, being present in what was thought to be a lymph node in the gross specimen. Many thin walled vessels traverse the neoplasm and hemorrhage is marked in many regions. In specially stained tissues this neoplastic tissue takes the stain in the manner of muscle cells (Figs. 1 and 2).

Diagnosis.—Primary leiomyosarcoma infiltrating all coats and extending into the periserosal tissues.

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INTESTINAL OBSTRUCTION FROM A FOOD BOLUS

TWO EPISODES IN THE SAME INDIVIDUAL

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INTESTINAL obstruction caused by a bolus of food is quite unusual. In a review of the literature in a 25 year period we have found no patient described in whom two distinct obstructions have been present at different intervals from such a cause. Chalmers'[8] patient had two intestinal obstructions seven years apart. The cause of the first was not stated, but the second was caused by a fig which had been swallowed whole. Elliott[10] collected 39 cases of intestinal obstruction caused by food within the 22 year period from 1910 to 1932, and added one of his own.

He noted that some of the predisposing factors appeared to be: (1) Increased age with an atonic digestive tract and concomitant abdominal pathology such as (2) stricture or neoplasm, (3) the habit of swallowing food whole, and finally, (4) the drinking of a large quantity of water with meals which might cause swelling of vegetable fibers, with a resuting increased bulk sufficient to cause obstruction. Table I (Elliott[10]) illustrates the type of obstructive material and the number of cases in the series which he collected from the literature.

TABLE I

Obstructing Material	Number of Cases	Obstructing Material	Number of Cases
(1) Mushrooms	5	(9) Grapes	2
(2) Cherries (stones)	4	(10) Poppy seeds	2
(3) Beans	4	(11) Ammunition bread	2
(4) Figs	3	(12) Sauerkraut	1
(5) Oats	3	(13) Gooseberries	1
(6) Potatoes	2	(14) Raisins	1
(7) Apples, pears and peas	2	(15) Half an orange	1
(8) Corn	2	(16) Popcorn	1
		(17) Bran	1

Table II shows the additional cases of bolus obstruction which have appeared in the literature since his report.

The most common site of obstruction from a food bolus is the terminal ileum, perforations are rare, and the symptoms usually come on within 12 hours after the material has been ingested. These are much the same as those noted in intestinal obstructions from any cause,[30] namely: pain, disten-

TABLE II

	Number of Cases	Causative Agent	Location of Obstruction
(1) Johnson[16]	1	Apricot	Ileum
(2) McIvor[23]	1	Green corn	Not given
	1	Bran	Not given
(3) Anderson[4]	1	Watermelon seeds	Rectum
(4) Lobsinger[21]	1	Japanese persimmon	Jejunum
(5) Altman[3]	1	Bone and peanut	Jejunum

tion, nausea and vomiting, and obstipation. Early relief of the obstruction is indicated.

Rarely a phytobezoar may pass out of its usual location in the stomach and cause an intestinal obstruction. Hart[14] mentions two such cases. In one individual, exploration revealed a phytobezoar in the stomach and another in the ileum, which was causing intestinal obstruction and impending perforation. In the other case a man ate, for the first time in his life, a large quantity of persimmons. He soon felt "sick all over." This discomfort lasted four or five days and then gradually subsided. Eighteen months later a roentgenologic examination showed a gastric ulcer. Laparotomy revealed a benign gastric ulcer, which was excised, and a gastro-enterostomy was performed. The patient felt well for seven months when he was suddenly seized with severe cramps. A diagnosis of intestinal obstruction was made and at operation a phytobezoar was found in the jejunum a few inches from the gastro-enterostomy opening. The obstructing mass was removed and was found to consist of persimmon seeds and pulp. It had apparently been present approximately two years and three months. Balfour and Good[5] quote Langenbuch who reported phytobezoars present simultaneously in the stomach and small intestine.

In general when intestinal obstruction is caused by phytobezoars there is a preceding history of gastro-intestinal distress for a period of weeks, or even years. Frequently the distress from the bezoar in the stomach simulates that of peptic ulcer, however, in the reported cases when the obstructing material passed into the small intestine, the severe cramps, prostration and other signs were prominent enough to warrant surgical intervention.

Case Report.—J. S., aged 68, was first examined because of an hyperfunctioning adenoma of the thyroid associated with an auricular fibrillation. These disorders were combined with coronary disease, indicated by inverted T-waves in leads II and III of the cardiogram. Because of the poor general condition and badly damaged heart, it was thought better to treat the patient medically. He was sent to the Wells County Hospital for several weeks' rest in bed, under which regimen he gradually improved.

He was very fond of apples and ate them frequently. His lower denture did not fit and he would not wear this plate when he ate and as a result he chewed his food very inadequately.

About six weeks after he was dismissed from the hospital, his physician stated that: "The day before becoming ill the patient had eaten apples after his evening meal. He had gone to bed and had awakened some hours later with severe cramping abdominal pain. Distention rapidly developed and peristaltic waves were visible through the abdom-

inal wall. Enemata were without effect." A diagnosis of intestinal obstruction was made. Abdominal exploration was performed at the Wells County Hospital.

Under ethylene anesthesia, a low right rectus incision disclosed an obstruction located in the ileum. Several proximal loops of intestine were red, engorged, and distended with gas and fecal material. An irregular mass approximately 6 by 5 by 4 cm., filled the lumen of the bowel. A Witzel type of enterostomy was performed, above the obstruction. After the distention was released it was possible by gentle manipulation to break up the bolus into small particles which it was thought would pass down the intestinal tract. The wound was closed. Fragments of the bolus that were examined when passed by the rectum, were pieces of apple. The patient made an uneventful convalescence.

For three months he remained well. He was then seized with intermittent abdominal cramps during the night. The bowels were moved inadequately with enemata. The symptoms of obstruction rapidly increased. At the end of 48 hours a second abdominal exploration was performed. The bolus had apparently passed along the small bowel, not completely occluding the lumen, until it came to an area where two loops were adherent. Here it became wedged and had caused a complete obstruction. The mass was broken up gently without opening the intestine, and a Witzel type enterostomy made in the most distended proximal loop.

The condition of the patient was poor when he left the operating table. The systolic pressure fell during the operation from 150 to 80. He succumbed the following day.

Postmortem examination demonstrated that the last obstruction and enterostomy tube were in the jejunum. The bowel contained pieces of vegetable material from 1 to 3 cm. in diameter which had formed the bolus. These could not be positively identified although they resembled raw potato. No neoplasm was found within the abdomen. There was bilateral hypostatic bronchopneumonia with pulmonary edema, and an old partial arteriosclerotic occlusion of the coronary arteries. There was an adenomatous hyperfunctioning thyroid.

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PLASTIC OPERATION ON THE QUADRICEPS EXTENSOR FOR OLD FRACTURE OF THE PATELLA*

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Case Report.—A male, aged 68, fell and fractured his right patella 32 years ago. It was sutured at the Pennsylvania Hospital. Ten years ago, in trying to save himself from falling, the same patella was again fractured. There was a separation of the fragments but the soft parts still gave fair stability and later on he was able to walk without crutches or cane. Last December, he fell on his right knee. All the structures were torn apart and he lost the power to extend his leg upon his thigh. He was able to walk with a cane.

At operation on February 27, 1935, the upper fragment was located at the junction of the middle and lower thirds of the femur. The lower fragment was below the level of the knee joint. An incision was made in the midline from the middle of the thigh to the lower edge of the lower fragment. Both fragments were exposed. The quadriceps muscle was so contracted and so resistant that the upper fragment could not be pulled down to anywhere near the lower fragment. Therefore the tendon and the aponeurosis of the rectus femoris was split down the middle and the outer half, including the vastus externus, cut away from the patella. At the upper end of this long median incision of the tendon, the inner half was cut across but not all the way through the vastus internus. A bundle of this muscle was left attached to the patella to provide it with a blood supply.

The upper fragment could then be pulled down to meet the lower fragment. The upper fragment was sawed across transversely near its lower edge, the cut being upwards and backwards. The upper edge of the lower fragment was sawed across transversely, the cut being upwards and backwards. The oblique cut surface of the upper fragment then overlapped the oblique cut surface of the lower fragment. Two holes were drilled through each fragment, one-third inch from the cut surface and the fragments were sutured firmly together with kangaroo tendon. A figure of eight suture of No. 2 chromic catgut was carried through the patellar tendon below and the quadriceps tendon at the upper edge of the patella. The cut ends of the tendon of the rectus femoris were sutured together and the capsule and tendon coverings sutured (Fig. 1). A plaster case was applied from the toes to the top of the thigh. This was cut down both sides so that the anterior shell could be removed for dressing and inspection. The knee joint was not moved for about six weeks. The limb was then removed from the plaster encasement, the knee joint moved through an arc of about 15° and the limb replaced in the case. Very gradually the range of motion was increased. The patient was able to go about with crutches and later with a cane. At the end of three months, a brace was substi-

* Presented before the Philadelphia Academy of Surgery, October 7, 1935.

tuted for the encasement. This has an interchangeable lock joint at the knee so that the range of motion can be regulated. He can now flex his knee almost to a right angle and extend it fully.

When sitting with his legs hanging over the edge of a table, he can easily extend his leg fully on his thigh, indicating good control by the quadriceps extensor. There

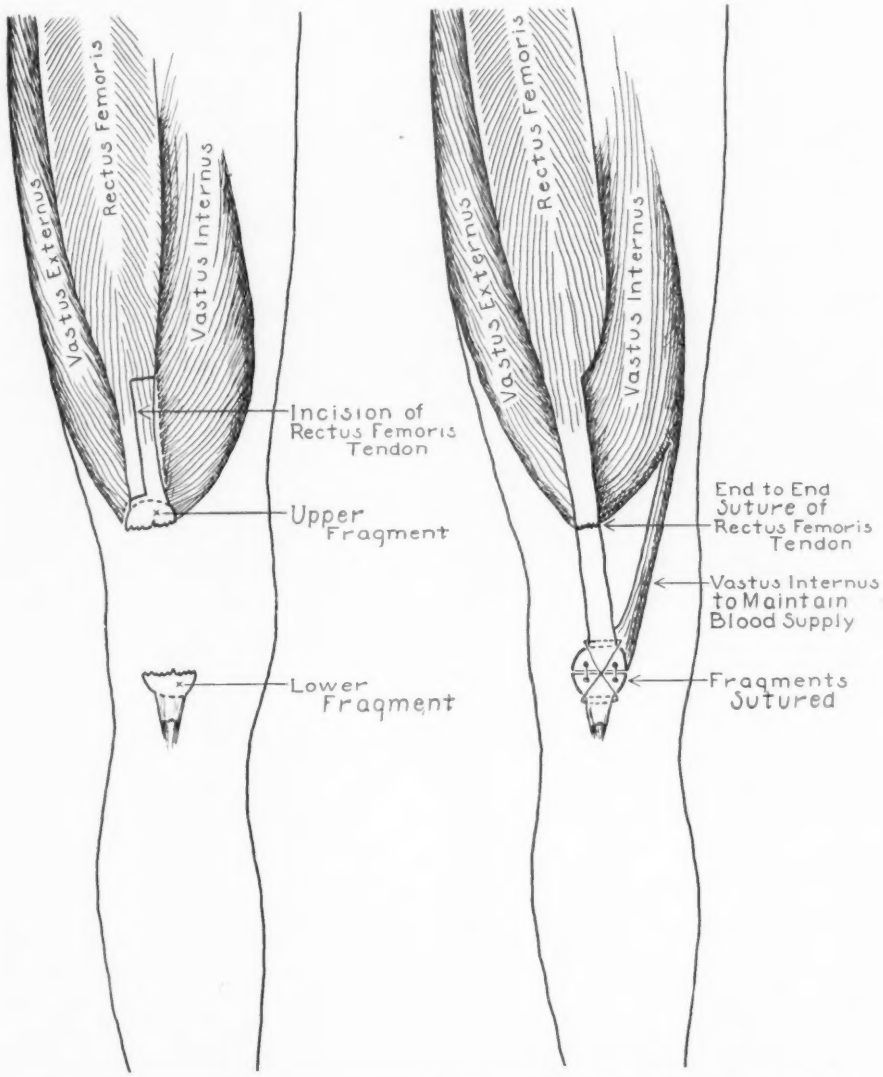

FIG. 1.—Illustrating the procedures described in the text, which were necessitated in order to approximate the fragments of the patella.

seems to be firm, dense, fibrous union of the fragments and the surrounding capsule. He walks easily and naturally without his brace but still wears it as a protection when he goes out of doors. This is adjusted to permit 45° of flexion at the knee. In another two months, it can probably be given up altogether.

A SIMPLE APPARATUS FOR THE CORRECTION OF FLEXION CONTRACTURE OF THE KNEE

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Various devices, excellent in theory but for the most part too complicated in construction or applicability to be used in general practice, have been reported for the correction of knee flexion contractures. At the Pennsylvania Hospital we have employed a simple apparatus which has rendered surprisingly good results, can be easily assembled from the usual ward equipment, and introduces advantages not heretofore obtained from any other apparatus designed for the same purpose.

The only materials required for the construction of the appliance are a Balkan frame, turkish towel, towel spreader, rope, pulley, and weights (Fig. 1). To set up the apparatus the towel is folded in half longitudinally, slung about the foot, the ends attached to the spreader, and the towel suspended from the Balkan frame by a rope. The foot is maintained at right angles with the ankle by a row of safety pins approximating the outer margins of the towel. To hold the foot securely a second row of safety pins is placed through the towel along the dorsum of the foot. A cotton-gauze doughnut is placed under the heel and the dorsum of the foot protected by cotton batting. The extension rope is made secure to the base of the towel by a slip knot and large safety pin. The rope is then run over a pulley at the foot of the bed, and traction obtained by means of weights.

In our experience a four to six pound weight has been sufficient to maintain adequate extension. The maximum elevation of the ankle from the bed should not exceed that of the knee; otherwise, part of the weight of the extremity is supported by the hip. For the patient's comfort, the thigh may be partially supported by a pillow without detracting appreciably from the amount of extension.

The extension obtained is the resultant of the force of gravity on the extremity and the pull exerted by the weight attached at the base of the towel. This arrangement conveys purely passive motion to the part. The patient can, by means of a suspended cross-bar, greatly increase the extensive force by lifting himself free of the bed and shifting his weight to the foot suspended in the towel. Thus, the apparatus affords active as well as passive motion which is limited only by the patient's pain threshold.

We have found this apparatus of great value in contractions of the hamstring muscles, contractures resulting from burns, and those following effusion into the knee joint. It has particular merit in knee flexion deformities where skin lesions prohibit the use of skeletal traction, wedging plaster encasements, and other mechanical devices. It can be employed safely in the presence of skin infections, phlebitis, deep burns, naevi, varicosities, edema of the leg, *etc.*, where the above mentioned appliances are contraindicated.

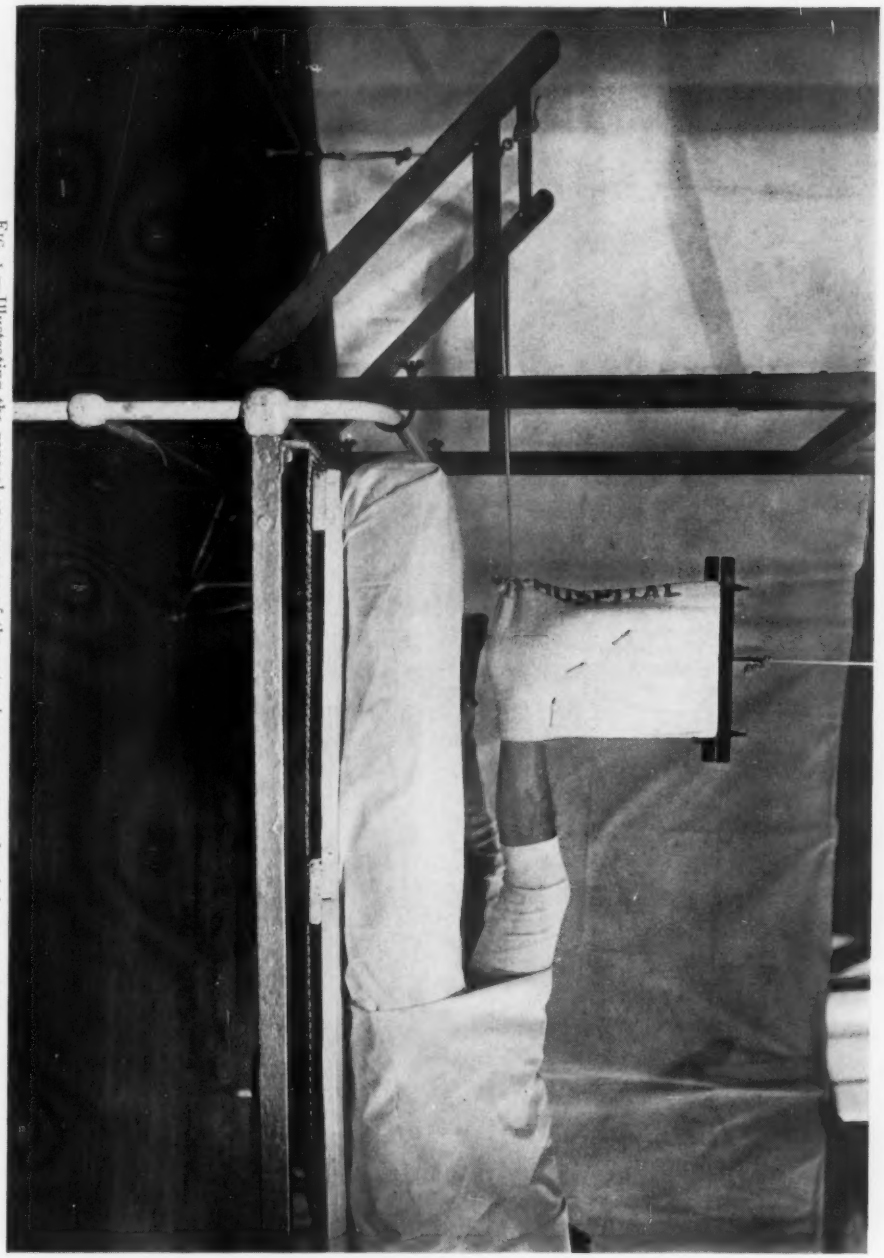

FIG. 1.—Illustrating the general appearance of the extension apparatus after being assembled.

Physiotherapy can be instituted simultaneously with the use of the apparatus with absolutely no inconvenience. An added advantage is the fact that it can be employed continuously or intermittently with a remarkable degree of comfort to the patient.

We believe that this conservative form of treatment should be given a thorough trial in all cases of knee flexion contracture and internal derangements from a mechanical cause, excluding ankylosis of the knee joint, prior to the use of a wedging plaster case or the more radical methods of skeletal traction, or operative procedures.

ADDENDUM

Dr. DeWitt Stetten, of New York City, advises me that he described a clamp similar to mine in the October, 1928, issue of the American Journal of Surgery. I was not aware of his instrument but wish to acknowledge any priority which he may claim.

The clamp which I described in the March, 1936, issue of the ANNALS OF SURGERY, differs from that of Doctor Stetten's in that the serrations on the jaws run transversely, are deeper, and intermesh so that it is impossible for the bowel to slip. In addition, the adjusting nut enables one to have a uniform pressure exerted along the entire length of the crushing surface. My clamp also has a crushing surface three and one-half inches long, which is a distinct advantage in individuals with fat, thick abdominal walls.

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MEMOIR

WILLIS FOREMAN WESTMORELAND

1864–1935

Dr. Willis Foreman Westmoreland was born near Milner, Ga., July 22, 1864, and died December 4, 1935, at his home in Atlanta. His father was Dr. Willis Westmoreland, a fearless soldier and the ranking surgical officer of the Confederate forces.

Willis Foreman Westmoreland, M.D.

Doctor Westmoreland was educated at the Kirkwood Military Academy, Atlanta, Ga., and Georgetown University, Washington, D. C. He graduated in medicine at the Atlanta Medical College in 1885. The breadth of medical education in that era was exemplified by his father's insistence that two years

should be spent as a graduate assistant in the offices of the leading medical and surgical men of the nation. His first six months were with Dr. J. Solis Cohen in Philadelphia, the leading throat specialist of his day. Then to New York with Janeway and Loomis in medicine. His second year was in the marvelous surgical environment of Dr. Henry B. Sands and Dr. William T. Bull, whom he accompanied daily in the Roosevelt and New York Hospitals. Finally he became an assistant to Dr. Lewis A. Sayre and his distinguished son, the late Dr. Reginald H. Sayre. They were the leading orthopedic surgeons of that period. This branch of surgery made a special appeal to Doctor Westmoreland, and for many years he was preeminent in this section in the practice of orthopedics in connection with his general surgical work.

Following the death of his father in 1890, he was elected to succeed him as the Professor of the Principles and Practice of Surgery in the Atlanta Medical College, assuming the responsibilities of this position at the age of twenty-six, and for twenty-five years maintained with dignity and brilliancy all the traditions of a great family of physicians and surgeons. In 1915, he retired from active teaching and was appointed Professor Emeritus of Surgery at his Alma Mater.

In chronicling the achievements of an outstanding surgeon and teacher his success is measured by the ability to impress and inspire his students in the ideals of the art and science of surgery and of the observance of the high principles of conduct obtaining among his professional confreres.

There was no need of his subscribing to the oath of Hippocrates, nor the necessity of following written rules governing and guiding his sense of professional fairness and honesty. His scrupulous respect for the opinion of all medical men and his unswerving defense of them, whether prominent or obscure, endeared him to them in a manner impossible for the written word to describe.

His enthusiasm for everything pertaining to medicine was an inspiration to all of us, and in the development of medical education and medical organization his talents were unexcelled. In medical politics he was a fair but relentless opponent, and in defeat was as generous and magnanimous as in the full enjoyment of victory.

Doctor Westmoreland was an idealist in the practice of his profession. Never a moment in his life was given to the thought of making money. To him money was a fleeting thing to be used only as a means of giving happiness to his friends, and to hold the ever open hand to the sick and afflicted poor.

It may safely be said for him that surgery was, indeed, the Queen of the Arts.

WILLIAM S. GOLDSMITH